POWER

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Seasonal Inspection

WHEN a steamer is in port, the engineer force is busiest, getting ready for another spell of uninterrupted operation.

In the winter time, when Nature is doing its own cooling, the engineer of a refrigerating plant finds time to overhaul things and get them in shipshape order for the season when continuous operation at capacity may be imperative.

In the summer time, when the heating plant is down, is the time to go over its details and put it into the best possible condition for the coming period of use.

What has been the effect of time and service upon the heating surface? Are coils free from corrosion and drained to prevent pitting while standing? If fans are used, are they and their motive power in good condition to stand the period of idleness and start up when needed? Are you sure from an inspection of each that all traps, valves, regulators, receivers etc., have come through the past season with their effectiveness and efficiency unimpaired, that they are guarded against conditions that will produce deterioration during the summer and be ready to function when the call comes for heat in the fall?

Some heating systems consist of nothing but a series of coils or radiators into which the man in charge admits steam more or less promptly when the tenants or operatives knock on the pipes. Others are arranged to keep rooms automatically at a desired temperature. The apparatus by which this is done is simple and ingenious, but no such device will function continually without attention. The engineer or master mechanic should understand their principles and mechanism and be able to adjust and restore them to operation or call upon the service department of the manufacturer, when they become deranged.

A little time spent in the inspection and touching up of such details in the season when they are out of use will save trouble later and perhaps prevent the throwing out of use of systems upon which much money has been expended simply for the want of the attention that any good mechanic could give.

F. R. Low

Steam Plant of Fisher Body Corporation

By C. K. LITTLE

Automobile Body Manufacturer Erects New 30,000-Sq.Ft. Boiler Plant—Fuel a Mixture of Coal and Lumber Scrap—Savings Over $18,000 per Month Compared with Costs When Operating Old Plant.

THE trade mark, "Body by Fisher" is now so well known that the new boiler house at Plant 18 of the Fisher Body Corporation, on West Fort Street, Detroit, Mich., has aroused considerable interest on the part of engineers. This plant is the largest automobile body factory in the world. During 1923 it produced 350 enclosed bodies per day complete from raw materials in the mill to finished product. For this production 1,934,000 ft. of lumber had to be seasoned by the dry-kiln process. To supply the 60,000,000 lb. of steam required per month for heating and process work, a new boiler plant was designed and erected by the company's engineering department.

The only available site imposed severe space limitations. It was hemmed in by railroad tracks on two sides, a driveway on the third side and a water tower on the fourth side. The ground area was approximately 114 ft. by 43 ft. giving an area of 4,914 sq.ft. Since 30,000 sq.ft. of boiler-heating surface was to be installed, the ratio of heating surface to floor space works out as over 6 to 1.

The limitation created by the small floor space was overcome by an unusual layout for an industrial heating plant. The boiler-room floor was located 18 ft. above the ground level; a mezzanine floor was then placed 9 ft. 2 in. above the ground level, and on this was installed the main steam header, stoker fans, air ducts and ash hoppers. On the ground floor was placed all the electrical equipment as well as the steam- and pipe-fitting departments for the entire factory. An ash tunnel was run through the entire building, directly beneath the ash hoppers, the ash gates themselves being flush with the mezzanine floor line. The tunnel was sealed from the rest of the building to prevent escape of dust and gases. Feed-water heaters were located on a balcony in the west end of boiler room, 14 ft. 6 in. above the firing floor, the boiler-feed pumps being set on the boiler-room floor beneath the balcony.

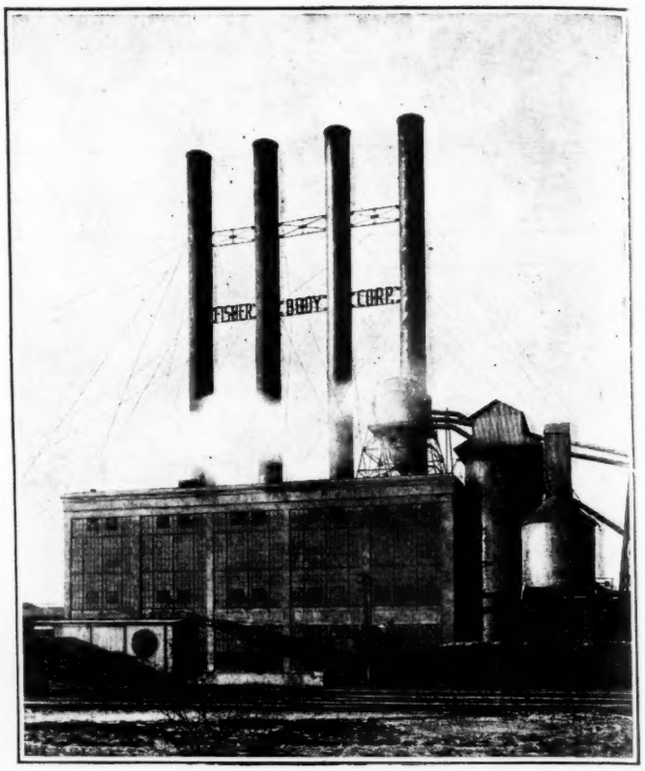


Fig. 2—Exterior of steam plant

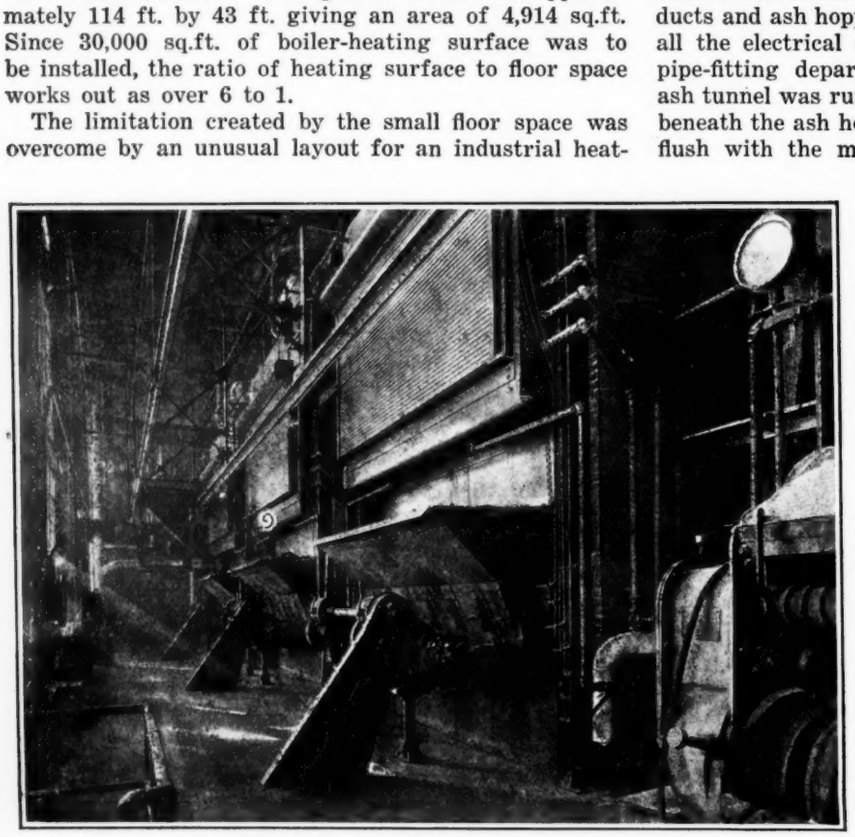


Fig. 1—View of firing aisle of boiler room

The latest type of equipment is used throughout, and no instruments or automatic control that was considered necessary for the most economical operation has been omitted. All instruments are of the indicating and recording type, indicators being mounted on panels in front of each boiler and the recorders and integrators in the chief engineer's office on the ground floor.

The building itself is of steel, concrete and brick construction, the larger portion of sides being made up of steel sash, the insides of the walls and roof having been put on with a cement gun. Ash gates, ash hoppers, stokers, boilers and stacks are carried on separate steel, inde-

pendent of the building steel, while there is a separately guyed steel stack for each boiler.

A coal storage of 500 tons is obtained by a re-elevating type of steel silo located just outside the east end, which is shown in Fig. 2. Coal spouts by gravity from the top of silo into an electric traveling weigh larry, from which it discharges into large extension hoppers on the stokers.

The Boiler Equipment

The steam-generating equipment consists of four horizontal water-tube boilers, each having 7,220 sq.ft. of heating surface and built for 200 lb. working pressure. These boilers are of the cross-drum type, with straight tubes and have horizontal baffling arranged so that both the inside or the outside of the tubes can be easily cleaned from either front or rear of the boiler.

The main steam header which encircles the mezzanine floor, is of the loop type to insure against an interruption to the factory supply due to an accident in any one section. Steam is supplied to various points of the factory at high pressure and is reduced in pressure just before entering the various processes or heating systems.

Water is returned from the heating and process systems at 150 deg. F. and passes through a horizontal open heater, 68 in. in diameter and 15 ft. long, having 700 sq.ft. of pan area. Directly beneath the heater is a V-notch meter, with a capacity of 200,000 lb. of water per hour. The recording mechanism is attached to the side of the meter tank, and as this complete unit is located on the boiler-room balcony, an extension mechanism is used so that the dials and recorder may be located about eye height above the boiler-room floor.

The boilers are fed both by two direct-acting steam pumps and by two centrifugal pumps; one of the latter is direct-connected to a 80-hp. steam turbine running at 1,750 r.p.m. and operating against 5 lb. gage back pressure. The second centrifugal is direct connected to a 75-hp. 1,800-r.p.m. induction motor. Fan turbines, stoker engines and steam pumps discharge into the heater at 1 lb. gage. The motor-driven pump permits a close regulation of the feed-water temperature, which is carried at 212 deg. F. The boiler feed is under automatic control, the valve parts of the regulator being of the compound type to cope with the extreme variation in the steam demand on the individual boiler.

Two Types of Stokers Used

Three of the four boilers are fired by gravity-type underfeed stokers, each seven retorts wide and twenty-one tuyeres deep, giving a projected grate area of 131 sq.ft. Each stoker is equipped with two spur-gear power transmission boxes which have two-speed variation for flexibility in fuel-bed control. This primary fuel-bed control is further supplemented by individual retort control. Overlapping distribution rams of the inclined-nose type form the entire bottom of each retort. Reciprocating overfeed extension grates convey the ash onto the steam-operated ash-dumping grates. Each of the two fans supplying the combustion air is capable of delivering 60,000 cu.ft. per min. at 6 in. static pressure, which is sufficient to develop over 250 per cent of nominal boiler rating for 14 retorts. A 92-hp. turbine drives each fan and operates at 1,380 r.p.m. with a water rate of 55 lb., with 200 lb. initial steam pressure and 5 lb. gage back pressure.

The fourth boiler is fired by a chain-grate stoker on which the kiln-dried hogged fuel is ordinarily burned. A cyclone on the building roof discharges into four spouts which spread the wood over the grate. Outside the power house are three large storage bins, the one for hogged wood having a capacity of 8,670 cu.ft. The hogged-wood bin is emptied by two worms which feed the material to a fan, and from there it is blown up to the cyclone. Both of the shaving bins, one with 5,780 and the other with 13,570 cu.ft. capacity, are emptied by one worm. The controllers for the motors that drive these worms are located on the boiler-room floor.

The wood refuse, consisting of shavings and hogged wood, averages about 8,500 B.t.u. to the pound, contains from 3.5 to 4 per cent moisture and may be burned on either the chain-grate stoker without a coal bed, or on unit No. 3, where it is burned on top of the regular fuel bed.

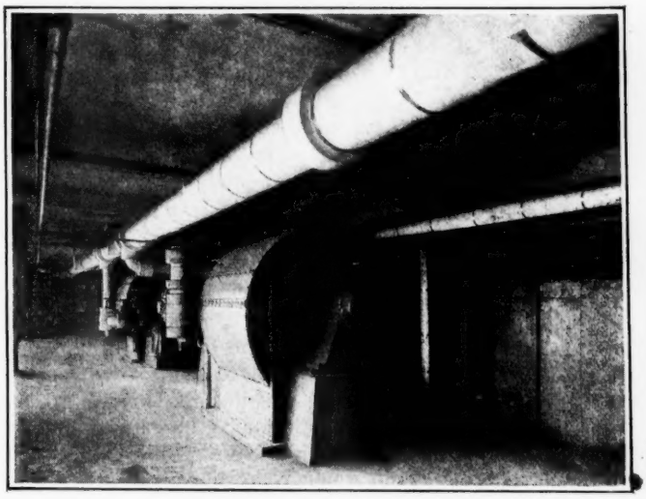


Fig. 3—Forced-draft fans and steam lines on mezzanine floor

Difficulty in weighing wood in sufficient quantities is responsible for the lack of accurate information concerning the relative evaporations of the two methods. Smokeless combustion is obtainable in either case, the main consideration being plenty of air; a secondary but important consideration is a large combustion chamber. In the case of the chain-grate stoker a fuel bed about 8 or 9 in. thick is maintained at the control gate, and this fuel bed is allowed to be completely consumed by the time it reaches a point about 3 ft. from the bridge wall. All the draft gates are open and in addition a steam pipe, placed beneath the arch, injects steam continuously into the furnace.

Firing with Wood Refuse

When burning wood on top of the underfeed stoker fuel-bed, the air necessary for combustion of the wood is injected over the fire just beneath the wood-feed spouts. This air is taken from a blower separate and independent of the main stoker forced-draft equipment.

If a thicker fuel bed is carried on the chain-grate stoker—that is, a bed from 10 to 12 in. thick—and is allowed to extend back completely to the bridge wall, it has been found that a CO_2 of 15 per cent might be obtained, but this was accompanied by a CO of 7 per

cent and a stack temperature of 750 deg. F. With the regular operating fuel bed of 8 in. thickness in the front, the fuel is completely consumed within 3 ft. of the bridge wall and gives a CO_2 of about 5 per cent and almost no CO. Nearly all the ashes are carried up the stack, and the ash hopper of this unit has to be dumped only once in a week or ten days.

The ash hoppers are constructed with steel frames lined with cast-iron plates to resist corrosion of quenching water should any leak through the locked tile that form the inner lining. There are two 3x4-ft. double piston-operated ash gates per hopper, constructed entirely of cast iron and lined with firebrick.

These gates give an action similar to a quick-acting valve and provide a means for the ash man to avoid an avalanch of ashes. The ashes drop from the hopper into an industrial car and from an outside pit are elevated by a skip hoist into a tile storage silo, from which they feed by gravity into a railroad car or truck.

Boiler-Room Instruments

Besides the V-notch meter attached to the feed-water heater, each boiler is equipped with a steam-flow meter, with its indicator on the boiler-room panel and its recorder and integrator in the chief engineer's office. Double inclined-tube draft gages indicate the over-fire draft, the breeching draft and the drop through boiler, while vertical gages show the air pressure in each stoker windbox. A three-unit CO_2 recorder is located in the engineer's office with three separate CO_2 indicators on the boiler-room floor, one on each unit panel.

These machines are of the latest type with new gas-conditioning equipment. Inside the breeching on the boiler side of the stack damper, the sampling pipe terminates in a self-cleaning double-disk filter. Beyond this a calcium-chloride drier removes any water from the gas sample and a special stone thimble removes corrosive sulphur compounds, so that gas enters the analyzer clean, dry and sulphur free. Another machine is provided, which records both CO_2 and CO; this is ordinarily connected to the wood burner, but can be thrown onto any one of the four boilers to test for CO.

A combustion-control system is provided for all coal-fired units. A constant draft is maintained over the fire, averaging about 1 in., by a stack damper regulator independent of the remainder of the control system. Negative pressure in the furnace is communicated to an oil-sealed inverted bell, which operates a control valve through a lever arm; the control valve moves a hydraulic piston which is directly connected to the stack damper.

Fan speed and stoker speed are controlled from the steam pressure, any variation in pressure being communicated to a balanced mercury column, which in turn moves a mercury piston. The mercury piston is connected to a control valve which operates a hydraulic piston, and this piston is connected to the fan turbine and stoker engine throttles.

The cost of the several parts of the boiler-house equipment in terms of cost per square foot of boiler-heater surface works out as in Table I.

TABLE I—COST OF EQUIPMENT

Equipment	Cost per Sq.Ft. of Boiler-Heating Surface
Boilers delivered	$1.425
3 underfeed stokers, 1 chain grate stoker, Drive and fans complete — delivered	1.240
4 ash gates and hoppers delivered	0.370
Settings including brick, fire-brick, common brick and clay	0.790
Erection of boilers, stokers, settings and hoppers	0.805
	$4.630
Pumps, heater, meters, water-softener (erected)	$0.285
Piping, covering, valves, specialties (erected); Governors and feed-water regulators (erected)	0.917
Instruments, panels and auto-regulation (erected)	0.200
Stacks and supports	0.483
Fire pump and piping	0.186
Electrical work (power) and transformers	0.355
Coal-and ash-handling equipment (erected)	1.820
Building (plumbing, heating, lighting)	5.480
Total cost per sq.ft. of boiler-heating surface	$14.356

During the month of December, 1923, 58,715,000 lb. of steam were generated and distributed as follows: 22,912,870 to dry kilns; 22,256,000 to dry ovens; 8,928,000 to power house; 4,618,130 to heating and

DATA ON FISHER BODY CORPORATION BOILER PLANT

GENERAL

Name	Fisher Body Corp., Plant 18
Location	West Fort St., Detroit, Mich.
Nature of demand	Industrial heating and process
Length of power house	113 ft. 9 in. outside
Width of power house	43 ft. 2 in. outside
Area of power house	4,914 sq.ft.
Distances:	
Boiler floor from ground, ft.	18
Mezzanine floor from ground, ft.	9.16
Balcony floor from boiler floor, ft.	14.50
Peak of roof from ground, ft.	73.00
Stack top from boiler floor, ft.	172.80

BOILERS

Manufacturer	Heine Boiler Co.
Type	Cross-drum
Baffling	Horizontal
Heating surface, sq.ft. each	7,220
Superheat	None
Working pressure, lb. gage	200 (present operating 140 lb.)

STOKERS

Manufacturer	Laclede-Christy Co.
Type	Stowe
Number	1
Manufacturer	American Engineering Co.
Type	Type "H" (gravity underfeed)
Number	3
Drive	Engine and jack-shaft

FORCED-DRAFT EQUIPMENT

Manufacturer	Buffalo Forge Co.
Number	2
Type and size	No. 7 TDH, with inlet guards
Capacity, c. f. m.	60,000
R.p.m.	1,380
Drive	Direct connected to 92-hp. type G. Terry turbine
Water rate of turbine, lb.	55

FEED-WATER HEATER

Manufacturer	Hoppes Mfg. Co.
Number	1
Diameter shell, ft.	6.8
Length, ft.	15
Pan area, sq.ft.	700

BOILER-FEED PUMPS

Manufacturer	Buffalo Steam Pump Co.
Number	2
Type	Duplex direct-acting steam drive
Size	10 x 6 x 12
Manufacturer	Union Pump Co.
Number	2
Type	Centrifugal
Drive	One direct-connected to a 2D Kerr Turbine, developing 80 hp. at 1,750 r.p.m. when operating on 200 lb. pressure against 5 lb. back pressure. One direct-connected to a General Electric 75-hp. induction motor.

MISCELLANEOUS EQUIPMENT

Valves	Jenkins Bros.
Coal and ash conveyors	Stearns Conveyor Co.
Ash gates and hoppers	Baker-Dunbar Co.
Cyclone, feeders and bins	Grand Rapids Blow Pipe Co., Mahon Roofing Co., Allington Curtis Co.
Feed water regulators	Northern Equipment Co.
CO_2 recorders	Uehling Instrument Co.
Draft gages	Lewis M. Ellison
Flow meters	Republic Flow Meter Co.
Recording thermometers	Brown Instrument Co.

RATIOS

Sq.ft. boiler heating surface per sq.ft. of power-house floor space	5.9
Sq.ft. powerhouse floor space, per sq.ft. of boiler-heating surface	.17
Sq.ft. of boiler-heating surface per sq.ft. of projected stoker area	.55
Cost per sq.ft. of boiler heating surface	$14.30
Cost per sq.ft. of power house	$84.00

miscellaneous. Of this total, 45,260,000 lb. was generated from coal and 13,455,000 lb. from wood refuse.

The cost per 1,000 lb. of steam generated is given in Table II. Column 1 is estimated by dividing the total cost for the month of December, 1923, by 45,260,000 lb.; that is, spreading the entire monthly cost over the steam generated from coal alone. This estimate is made simply for the sake of comparison. Column 2 is estimated on a basis of 58,715,000 lb. and is the actual cost per 1,000 lb. making no charge for wood refuse.

TABLE II—COST OF STEAM GENERATION

	December, 1923 Cost per 1,000 Steam	
	1	2
	Cents	Cents
Coal (2,309 tons at $5.15)	25.3	19.5
Payroll (19 men)	9.0	6.9
Supplies	0.6	0.5
Makeup water	0.8	0.6
Repairs	0.7	0.6
Depreciation, taxes, insurance	8.0	6.2
Total, cents	44.4	34.3

NOTE: Depreciation is figured at various rates for different items. No fixed interest charge is made against this plant.

A comparison of the costs with the old and with the new plant brings out some interesting points. It will be noticed that the actual outlay in December, 1923, was less than the outlay in December, 1922, when the plant was in operation; while the output with the new plant was 50 per cent greater than in 1922.

TABLE III—COMPARISON OF OLD AND NEW PLANT GENERATING COSTS

	Dec. 1923 (New Plant)	Dec. 1922 (Old Plant)
Coal (2,309 tons) Payroll Supplies Makeup Repairs Depreciation, taxes, etc.	$20,191.86	$22,879.75
Total lb. steam generated	58,715,000	35,000,000
Lb. steam from coal	45,260,000	24,500,000
Lb. steam from wood	13,455,000	10,500,000
Evaporation per lb. coal, lb.	10.7	4.0
Cost per 1,000 lb. (coal basis), cents	44.4	93.5
Cost per 1,000 lb. (coal and wood basis), cents	34.3	65.5

The cost department of the corporation estimates that by the erection of the new power plant a saving of $18,150 was effected for the month of December, 1923, due to higher evaporation per lb. of coal and reduction in labor required.

The original part of this factory was not built by the Fisher Body Corp., but purchased by it after the war and the original owners had built the first sections of the factory with small, high-pressure piping. To permit the use of exhaust steam from a generating unit would have made it necessary to rip out this piping and replace it with larger piping for the lower steam. The capital outlay necessary has not seemed justified up to the present time. Provision has been made, however, in the power-house construction for the installation of a generating unit and the management is considering this change very strongly for the near future.

The policy of this company is to generate all the power possible from the steam which is necessary for the kilns and ovens, but it has one or two exceptional cases of this kind where, during the past few years, thermal efficiency did not correspond to economic efficiency.

During 1923, Italy received 486,112 tons of coal from the United States against 128,443 tons in 1922, according to Italian import statistics. If imports from the United States are maintained for the remainder of the current year at the same rate as during the first quarter, the total for 1924 will be around 620,000 tons.

Power for Textile Mills*

BY CHARLES T. MAIN

The chief items of the cost of textile manufacturing are materials and labor. The cost of power is rarely over 5 per cent of the total cost of the product of the mill, and while the cost of power is an item that should receive careful consideration, it is of more importance to locate in some place where a sufficient number of operatives can be procured and where reasonable freight rates can be made, than to locate where power is cheap and the other items lacking.

With the exception of some plants of small size, nearly all the power installations being made in textile mills now use electric transmission. In the earlier electrical installations it was common to use large motors, 100 hp. or more in size, to drive large groups of textile machines. There has been a continuous tendency to decrease the size of the group of machines driven by one motor and to use the individual motor for each machine. It is common practice now to limit the size of motors for group drives to about 40 or 50 hp., and to use individual motors ranging in size from ½ hp. to about 10 hp. on many of the textile machines.

With regard to the conditions that affect the power problem, textile mills may be divided into two general groups:

(a) Plain goods cotton mills, which require little or no steam or warm water in their manufacturing processes, and other similar mills.

(b) Woolen and worsted mills, which require large amounts of steam and warm water in their finishing processes, and so can make use of the waste heat from the generation of power, and similar mills.

There is, roughly, 1¼ million horsepower used by the cotton mills and about ¼ of a million horsepower used in the woolen and worsted mills in this country.

COST OF STEAM POWER USING STEAM TURBINES

In most textile mills, the power plant will vary from 1,000 to 5,000 kw. capacity. With a modern plant, the following figures for cost of installation and operation are fair, when no steam is used for anything but power:

Items of Cost*	Size of Plants in Kilowatts and cost of items 1,000	2,000	3,000	4,000	5,000
Cost of plant per kilowatt	$180.00	$150.00	$130.00	$120.00	$110.00
Coal per kilowatt-hour in pounds	3.1	2.7	2.6	2.4	2.2
Yearly cost per kilowatt with coal	$60.00	$52.00	$47.50	$43.00	$43.00
Cost per kilowatt-hour in cents	2.8	2.4	2.2	2.0	2.0
Yearly cost per kilowatt with oil	$56.00	$47.50	$45.50	$43.00	$43.00
Cost per kilowatt-hour in cents	2.6	2.2	2.10	2.0	2.0

*In making up the cost of steam power, all charges have been considered except interest and taxes on the cost of land. The fixed charges, including depreciation, repairs, insurance and taxes, have been assumed at 12.5 per cent. and the running time 50 weeks of 48 hours each, or 2,400 hours a year. The cost of coal is assumed at $8 per short ton delivered in the coal pocket, and oil at $1.80 a barrel.

In many places mills run longer hours than 48 a week, and coal can be delivered at $4 a ton, and construction costs are less.

With 54 hours a week and $4 coal, and no change in cost of plant, 1,000 kw. could operate at $48.70 a kw., or 2c. a kw.-hr., all costs included, and 5,000 kw. could operate at $35.60 a kw., or 1.47c. a kw.-hr., all costs included.

*Excerpts from paper presented at World Power Conference.

It has been common practice for many years to use exhaust steam of non-condensing engines and steam from the receivers of compound engines for manufacturing purposes and for heating buildings.

The saving by the use of exhaust steam, which would otherwise go to waste, is considerable. In some mills, especially colored mills, if the power is not produced by steam, so that the low-pressure steam can be used for manufacturing purposes, it would be necessary to maintain a boiler plant of sufficient size to produce an equivalent amount of exhaust or receiver steam thus used.

The bleeder type of steam turbine lends itself to this manner of running better than the reciprocating steam engine and supplies steam free from oil for process work.

The reduction effected by the use of low-pressure steam upon the net cost is shown approximately in the following table:

Per Cent of Steam Used	Coal at $8 — Per Kilowatt-Year	Coal at $8 — Per Kilowatt-Hour
25	$10 to $11	0.45 to 0.5 cents
50	16.50 to 17.50	0.75 to 0.8 cents
75	21.50 to 25.00	1.00 to 1.15 cents
100	28.00 to 33.00	1.30 to 1.50 cents

Cost of Hydro-Electric Power

The following table shows in a general way the cost of power under varying conditions of cost:

APPROXIMATE COST OF UNIFORM HYDRO-ELECTRIC POWER					
Size of plant in kilowatts	1,000	2,000	3,000	4,000	5,000
Assumed cost per kilowatt	$100.00	$100.00	$100.00	$100.00	$100.00
Yearly cost per kilowatt	14.00	13.25	12.50	11.75	11.00
Cost per kilowatt-hour in cents	0.65	0.61	0.57	0.53	0.50
Assumed cost per kilowatt	$200.00	$200.00	$200.00	$200.00	$200.00
Yearly cost per kilowatt	25.00	24.35	23.45	22.60	21.75
Cost per kilowatt-hour in cents	1.17	1.13	1.09	1.05	1.00
Assumed cost per kilowatt	$300.00	$300.00	$300.00	$300.00	$300.00
Yearly cost per kilowatt	36.20	35.30	34.40	33.55	32.65
Cost per kilowatt-hour in cents	1.70	1.65	1.60	1.55	1.50

The costs given are for current on the switchboard in the generating station. Adding 10 per cent to the last set of figures in the preceding table, we have the approximate cost at the end of the line assuming the cost of plant and line at $300 a kilowatt.

Size of plant in kilowatts	1,000	2,000	3,000	4,000	5,000
Yearly cost per kilowatt	$39.80	$38.80	$37.80	$36.90	$35.90
Cost per kilowatt-hour in cents	1.87	1.82	1.76	1.71	1.65

Purchased Power

Assuming that the mill will consider the purchase of power on a basis of cost of production by its own plant, how much can it afford to pay for the same?

1. A plain cotton mill, having use for exhaust steam for heating and slashing only, could afford to pay for guaranteed power about as follows:

Capacity of Plant	Running 48 Hours a Week — Per kw.-year	Coal at $8 — Per kw.-hour	Running 54 Hours a Week — Per kw.-year	Coal at $4 — Per kw.-hour
1,000 kw.	$56	2.6c	$46	1.9c
5,000 kw.	$43	2.0c	$39	1.6c

2. A colored mill, using about three-quarters of the waste heat from the power plant in manufacturing, could pay:

1,000 kw.	$31	1.4c	$27	1.1c
5,000 kw.	$22	1.0c	$21	0.9c

3. With an established mill with a good power plant all built, the mill has its investment in steam plant to charge off and it could afford to pay an amount somewhat less than if it were a new mill and could save the investment in steam plant.

What a Charge of Salt Solution Looks Like After Traveling 18,000 Feet in a Pipe Line

By Edwin A. Taylor*

In the issue of *Power* for April 29, 1924, an article appeared describing the salt-velocity method of water measurement and showing some of the experimental work carried on during the early stages of development. A part of that article, including several sketches, was devoted to illustrating the author's conception of the appearance of a charge of salt water injected into a pipe carrying fresh water. Since the tests on which that article was based, other tests have been made and additional light has been shed on the behavior of a charge of salt water passing through a long pipe.

In June, 1923, an efficiency test was made on the Searsburg, Vermont, unit of the New England Power Co.'s system. The water for this unit is taken from a reservoir on the Deerfield River, about three miles north of the power house, and brought to the wheel by 18,700

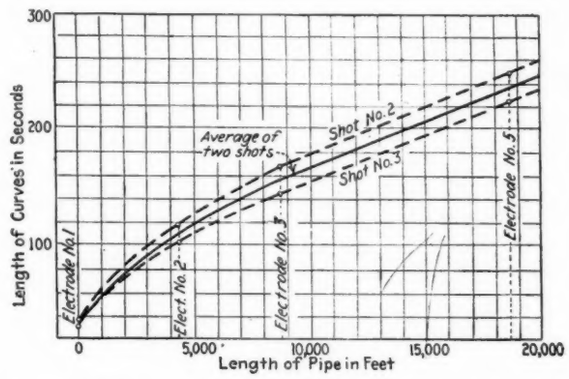


Fig. 1—Shows a curve of the length of salt charge in seconds plotted against feet of pipe

ft. of 8-ft. wood-stave pipe and 500 ft. of 6-ft. 6-in. riveted steel pipe.

The discharge through each pipe was measured, and in addition to providing checks in connection with the efficiency test, the opportunity was taken to study the dispersion of a charge of salt in the long wood-stave pipe. Brine was introduced by the barrelful through a pop valve at the reservoir gatehouse. Five improved electrodes[1] were placed on the horizontal diameters of the pipe at varying intervals. Unfortunately, electrode No. 4 went out of commission just before the test started and was not repaired. The lengths of the section of pipe between the four remaining electrodes were as follows:

Section	Electrodes	Feet
0	From salt introduction to electrode 1	50
1	From electrode 1 to electrode 2	4,365
2	From electrode 2 to electrode 3	4,415
3	From electrode 3 to electrode 5	9,854
	Total from electrode 1 to electrode 5	18,634

One trial shot[2] was made, and this shot was timed for one section only. Two final shots were made, and

*Hydraulic engineer, Worcester, Mass.

[1]See article "The Salt Velocity Method of Water Measurement," by C. M. Allen and E. A. Taylor, in *Mechanical Engineering*, December, 1923.

[2]A charge of salt solution.

all three sections were timed for each shot. The discharge rates computed from the centers of gravity for the salt charge curves, for the three shots, are given in the following:

Shot Number	Sections	Second-Feet
1	2 (only)	316.9
2	1	316.4
	2	316.9
	3	317.4
3	1	316.9
	2	317.5
	3	317.4
	Average.....	317.1

The discharge indicated by a penstock needle valve calibrated as a venturi meter was 317.5 second-feet for the period covered by the last two shots.

The length of the curves indicating the salt passing each electrode (the total length of the salt charges in the pipe, in seconds) for the last two shots are for electrodes Nos. 1, 2, 3 and 5, and No. 2 shot, 18, 118, 169 and 251 seconds respectively; for No. 3 shot, 15, 103, 145 and 225 seconds respectively. For shot 3 the barrel was not quite full of salt solution, which probably accounts for the curves being somewhat shorter than those for shot No. 3.

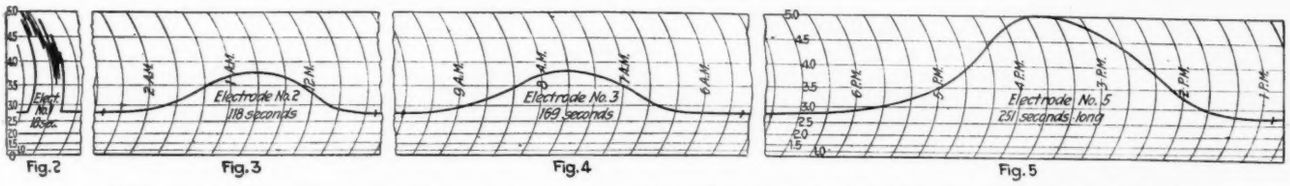
Fig. 1 shows a curve of the lengths of salt charge, in seconds, plotted against feet of pipe. Figs. 2, 3, 4 and 5 show the ammeter curves for shot No. 2 passing each electrode.

The maximum deflection of the needle, which records the current in amperes, varies with the density of the salted water, but the resistance to the passage of this current is affected by the length of wire between the electrodes and the recording ammeter. Electrode No. 5 was only 500 ft. from the meter, and electrode No. 3 was over 10,000 ft. away. The shorter wires for electrode No. 5 more than offset the loss in density by dispersion, which accounts for the high curve while salt was passing the last electrode.

Since the velocity of water in the pipe was about 6.3 ft. per sec. and the salt-solution charge was 18 sec. in passing electrode No. 1, this charge was about 6.3 × 18 = 113.4 ft. long when it passed this electrode. At electrode No. 5 the curve is 251 sec. long, therefore it represents a length of 6.3 × 251 = 1,581.3 ft. In other words the charge has increased in length 1,468 ft. but still can be recorded on an ammeter in such a way as to give an accurate measure of the water velocity in the pipe line.

Fig. 6 shows the author's conception of the shape of the second salt charge passing electrode No. 5. The dimensions, in seconds, are those shown by the ammeter curve. These dimensions and the points *A*, *B*, *C* and *D* are fixed very definitely by the curve, but the points *E* and *F* are only approximated.

Before the tests, several engineers predicted that the salt would be so spread out that no curve (deflection of needle) would be visible at the lower electrode, No. 5. Others predicted that a perfectly good curve would appear even if the pipe was ten miles long. The author hopes to be able to test out the last theory on a very long pipe.



Figs. 2 to 5—Shows shape of ammeter curve obtained as No. 2 salt charge passed each electrode

The number of seconds required for the charge to pass each electrode is given to each figure.

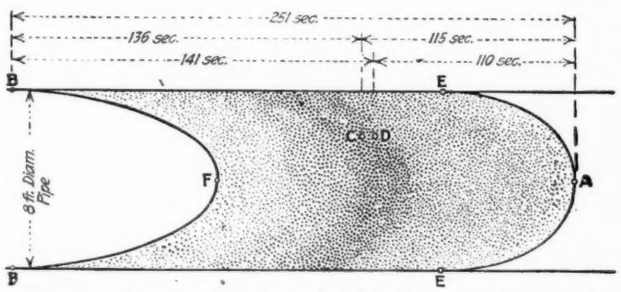


Fig. 6—Assumed shape of salt charge as it passed electrode No. 5

Insufficient Ammonia Charge

An insufficient charge will be indicated by a sputtering sound in the expansion valves, and the frost line on the expansion valves will disappear; and if the valves are opened too much in an attempt to get the frost back to the machine, the valves, liquid header and the liquid line for some distance back will become frosted. This is because the expansion valves are opened so wide that the liquid line is unable to furnish the supply. The head pressure and back pressure will come down, the frost will disappear from the suction side of the machine, and the latter will run hot. Oil, poor ammonia and frosted coils will all have the same effect. The back and head pressure will drop, and the expansion valves will have to be closed more to accommodate the slower rate of evaporation.

Excessive head pressure is another frequent trouble. This is caused by air or foul gas in the system, condenser badly scaled on the water surface, oil in the condenser or some of the condenser coils blocked. In a double-pipe condenser the water pipes are readily scaled if the water is not of the best; the annular space between the pipes is small, and this sometimes blocks with oil, scale and other foreign matter. Generally, if this happens a number of the stands will be cold, and by going along the condenser and feeling them, the "dead" ones can be located. These should be shut off with the water running on them and left standing for a few hours and then purged. This will decrease the head pressure. If the condenser is too small or the water warm or insufficient, high head pressure will be practically impossible to avoid.

There must be enough ammonia in the system to insure a solid stream of liquid going through the expansion valve, and there should be enough vapor evaporated from the liquid to make the evaporating coils take up heat equal to the capacity of the plant. In addition there must be enough surplus to allow for loss by leakage and for possible pocketing of the liquid.

Calorimeter for Steam Investigations Developed by Bureau of Standards

By P. W. SWAIN*

AS STATED in an introductory article in the Aug. 5 issue, the A.S.M.E. is sponsoring an extensive program of research for the purpose of perfecting and extending the fundamental steam-table data. The research work, which is being carried on jointly by the Bureau of Standards, the Massachusetts Institute of Technology and the Harvard Engineering School, is well advanced. Revised steam tables based on these investigations, which will give engineers trustworthy data for high pressures and temperatures as well as for the lower ranges, will probably be available within a few years. Two later articles will cover the work on the pressure-volume-temperature relation at the Massachusetts Institute of Technology and that on the Joule-Thomson effect at Harvard.

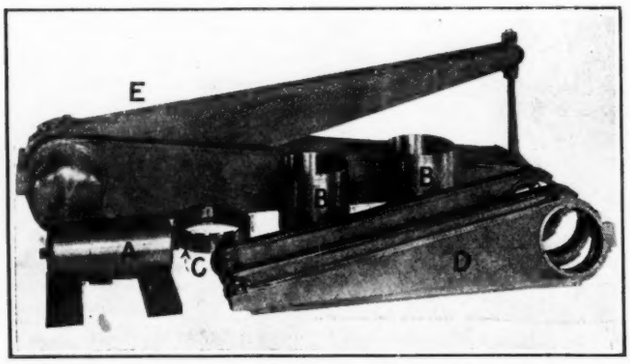


Fig. 1—Calorimeter shells and special wrenches used in assembling them

A—Three-inch copper-nickel shell assembled. *B*—Parts of 4-in. shell for casing. *C*—Right-and-left-threaded bands for 4-in. shell. *D*—Set of wrenches for 3-in. shell. *E*—Manner of using wrenches.

The present article is concerned with the research work at the Bureau of Standards, where N. S. Osborne and H. F. Stimson have developed highly refined methods and apparatus for measuring the energy required to warm up and evaporate water. Their work will give directly a precise value for the B.t.u. in energy units and all the steam-table data for liquid water and saturated steam. Building upon this data and to a certain extent checking it, the results obtained at "M.I.T." and Harvard will complete the steam tables for the superheated region. These tables will probably include actual experimental data up to around 1,200 lb. and 700 deg. F., while extension of the formulas developed for this range should give reasonably accurate values for considerably higher pressures and temperatures. The Bureau of Standards was selected for the heat measurements on water and saturated steam because of its experience in and facilities for work of this sort. In obtaining the data for the Bureau's recently published ammonia tables, Messrs. Osborne and Stimson encountered and solved problems similar to those of the present investigation. Modern improvements in laboratory appliances and methods have been utilized, such, for example, as the measurement of heat added and temperature by electrical methods, which excel in accuracy, reliability and convenience. With the experience gained in the ammonia work, the design of a somewhat similar calorimeter has, after much experimentation, been developed for the steam research, and the instrument is being constructed.

On first thought the problem of determining the value of the heat unit and the liquid and latent heats might seem easy. Assuming that the water is electrically heated, the fundamental requirements are simple enough. The electrical energy required to heat one pound of water from 32 deg. F. to 212 deg. divided by 180 gives the value of the mean B.t.u. in units of electrical energy. The mechanical equivalent of electrical energy is known with great accuracy, so the value of the B.t.u. in foot-pounds is easily obtained from the same data. Then the heat of the liquid could be found directly by measuring the amount of electrical energy required to heat one pound of water from 32 deg. to the given temperature. In the same way a measurement of the energy required to evaporate one pound of water would give the latent heat.

It is, however, practically impossible to make such measurements directly. The water and steam must be held in a container of some sort. When the temperature rises, this container will absorb part of the heat. In measuring liquid heats some of the water will evaporate, this amount increasing as the temperature is raised. It would be necessary to account accurately for the relative amounts existing as liquid and vapor. The total volume of the container could be measured, but even here allowance would have to be made for its expansion with increasing pressure and temperature. It is therefore necessary to conduct the experiments in such a manner that these disturbing factors can be allowed for to a high degree of accuracy.

There are still other practical requirements. The container must be tight and safe at pressures up to 1,200 lb. per square inch or higher. It must not be attacked by hot water. The electrical heating coil must be capable of evaporating

AS ITS share of the A.S.M.E. steam-research program the Bureau of Standards has assumed the difficult task of redetermining the amount of energy in one heat unit, and of measuring the heat content of water and latent heat of vaporization up to as high a pressure as possible (probably 1,200 lb.). The calorimeter is a shell of copper-nickel alloy, heavily silver plated inside to resist corrosion by the hot water. Measured amounts of heat are introduced into the inclosed water by an electric heater. A $\frac{1}{7,000}$-hp. centrifugal stirring pump within this shell circulates 800 lb. of water per hour. An extremely refined method of experimenting has been developed to insure the utmost reliability.

*Assistant Editor of *Power*.

water quietly without priming or superheating. This is an absolute essential for reliable results. Provision must be made for copious stirring. This is a particularly difficult problem, as will be shown later. Loss of heat from the container or "bomb" must be reduced to a minimum, and provision must be made for closely estimating the loss that does occur in order that suitable corrections may be made. Instruments and connections must be provided for the accurate measurement of pressures and temperatures.

With the traditional methods of conducting such experiments it would also be necessary to determine with great accuracy not only the weight of water heated and of steam evaporated, but also the heat capacity of the bomb itself, and its volume at all pressures and temperatures. The Bureau of Standards has developed an experimental method that makes these auxiliary measurements unnecessary.

Before describing the actual apparatus, something should be said of the theory of this method, which was developed as a result of a rigorous mathematical analysis of the problem. It was found that if three sets of measurements were made and the results properly combined, all these undesired constants would drop out, so that liquid, latent and total heats (and incidentally specific volumes as well) could be determined with no other measurements than energy supplied, temperature and pressure and the weights of fluid introduced into and removed from the bomb.

While it is impossible to explain this method fully without involved mathematics, a few simplified illustrations will give some idea of it.

Fig. 2 represents an electrically heated "bomb" filled with water and steam with provision for removing weighed quantities of water or steam and also for adding weighed quantities of water. The sketch is

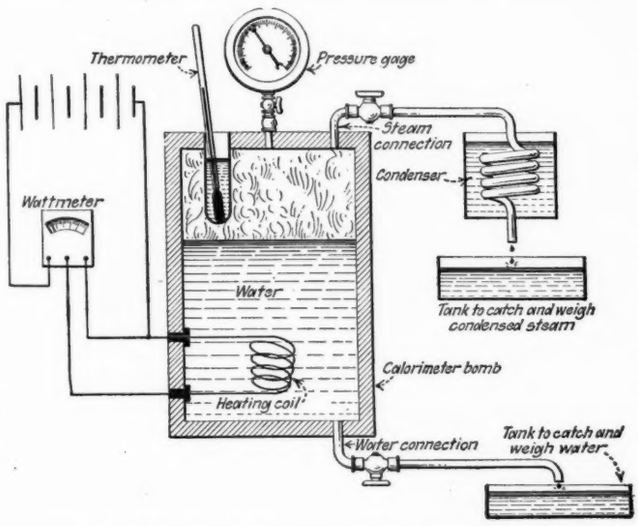


Fig. 2—Idealized diagram of bomb with essential instruments and connections

This apparatus, shown only to illustrate the principle involved, is purely diagrammatic and bears no resemblance to the actual apparatus.

purely diagrammatic and bears no resemblance to the actual apparatus, which is of a highly refined nature.

It is not necessary to measure the cubical contents or heat capacity of the bomb or the total amounts of steam and water it contains. Three types of experiments will give all the desired data.

The first is illustrated in Fig. 3. A weighed quantity of steam—say one pound—is gradually removed from the top of the bomb, while electrical energy is supplied to keep the temperature constant. In the next experiment, Fig. 4, the initial condition is exactly the same, but one pound of fluid is removed from the bottom of the bomb as *liquid water*, while energy is again supplied to keep the temperature constant. The

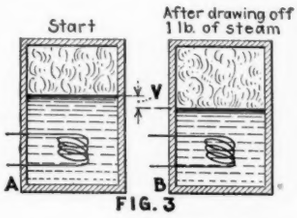


FIG. 3

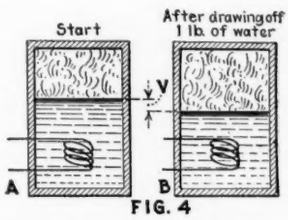


FIG. 4

Figs. 3 and 4—Withdrawing a pound of steam at constant temperature takes much more heat than withdrawing a pound of water. The difference is the latent heat

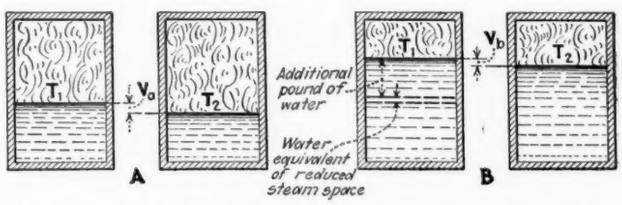


Fig. 5—The fall in water level when the sealed shell is heated from T_1 to T_2 varies with the amount of water in the shell at the start

final condition will then be the same as before, but much less heat will be required than in the first experiment.

In the first, heat must be supplied to evaporate the pound of steam removed plus the small additional weight in the added volume V due to the lowered water level. In the second the only steam produced is that required to fill the volume V. Taking the difference gives the heat required to evaporate one pound of steam.

Fig. 5 illustrates the third experiment, which must be made in two steps. In A all outlets are closed and the bomb is heated from a temperature T_1 to another T_2, the amount of heat required being measured. The effect here is more complex. Some of the heat is taken up by the material of the bomb. Some is used up in heating water and some in evaporation.

At B the same procedure is repeated with an additional weight (say one pound more) of fluid in the bomb. This will take more heat than before. There will be no change in the amount required to heat up the bomb or the original weight of water. Most of the additional heat will go toward heating up the additional pound of water. There will, however, be a correction due to the fact that the decreased steam space in the second run will reduce the amount of water evaporated. That is V_b will be different from V_a. This correction involves the relative specific volumes of water and steam.

While the actual computations are too mathematical to take up here, it should be noted that Mr. Osborne has developed rational formulas by which the heat quantities measured in these three experiments can be combined to give the following quantities: Heat content of the liquid, heat of vaporization, heat content of the

saturated vapor, the entropy, specific heat, and specific volumes of water and steam.

This method, eliminating the most important sources of error and trouble, is fundamental to the success of the work. Without it the desired accuracy could not be attained.

The actual bomb (see Figs. 1 and 6) is made of a nickel-copper alloy and silver-plated on the inside to resist the action of the water. Its capacity is about 1½ lb. of water. A double-threaded nut is used to bring the two halves together upon a solid silver gasket in a tongue-and-groove joint. This nut is made of a material having slightly lower coefficient of expansion than that of the bomb, so as to tighten the joint as the temperature is raised. The bomb is inclosed by an outer shell. Heat loss is practically eliminated by keeping the two shells at the same temperature and maintaining a vacuum in the space between.

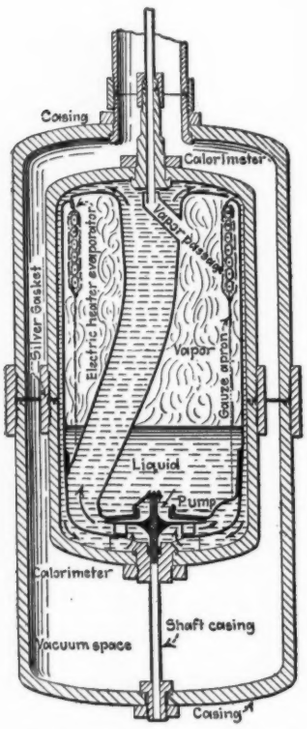


Fig. 6—Cross-section of actual calorimeter

Probably the most remarkable feature of this calorimeter is the centrifugal pump used for circulating the water to maintain uniform conditions. It is, of course, easy enough to make a small pump. The difficulty lies in the fact that the shaft has to be packed in a way to avoid any leakage at high pressures, and that the power delivered to the impeller must be both small and constant. The energy delivered to the impeller heats the water and has to be added to that delivered by the electrical heating coil. If this energy is not extremely small and reasonably constant, the correction for it will be sufficiently in error to cause trouble.

A special study was made of pump design. After three months of work, in which the many impellers and several casings shown in Fig. 7 were built and tested, a pump was constructed to operate on a power consumption of only 0.1 watt while circulating 800 lb. of water per hour. This was a remarkable achievement. Some of the pump parts are of pure silver and others of gold-silver alloy, while the miniature ball bearings on which the impeller runs are of iridium-osmium alloy.

From the cross-section it will be seen that the impeller has a divided suction, the lower portion circulating about 650 lb. of water per hour against a net head of about one inch, while the upper takes care of the smaller amount of water that flows down from the heater coils.

This smaller portion must be pumped against a maximum net head nearly equal to the height of the calorimeter (about 5 in.). On account of this difference in working conditions the blades of the upper section of the impeller are much longer and narrower than those of the lower.

The coil is made of heater wire embedded in clay within a flattened tube of pure silver and wound in a helix. This tube is covered with silver wire cloth to keep the surface wet. Water flows in a thin film over the entire surface and passes off quietly by a silver gauze apron reaching down below the liquid level. Tests have shown that this coil will evaporate water at the required rate quietly and without priming.

Temperatures will be measured by resistance thermometers and thermocouples. Pressures will be measured either by mercury manometers or by accurate piston gages which balance the steam pressure against standard weights.

The big job in work of this kind is the development of proper apparatus. The actual making of the final measurements also requires great care and several observers, but is not so formidable if the preparations have been thorough.

The Bureau of Standards has taken the attitude that this work, to be of value, must employ more refined methods and apparatus than have been available heretofore in experimental studies of saturated steam.

The attempt to design and construct the complete apparatus from preliminary designs would invite failure. Instead, the actual procedure has been to develop each part separately. By continually repeating the process of design, construction and testing, each element is perfected before any attempt is made to combine the elements. Then final tests and adjustments may be made on the completed apparatus.

While the preliminary work at the Bureau of Standards seems to be nearing completion, unforeseen delays may occur in running down the troubles which consume so much of the time and energy of research workers. It is probable, however, that in another two years this work, along with that at the other two institutions, will be yielding actual steam data that will make it possible

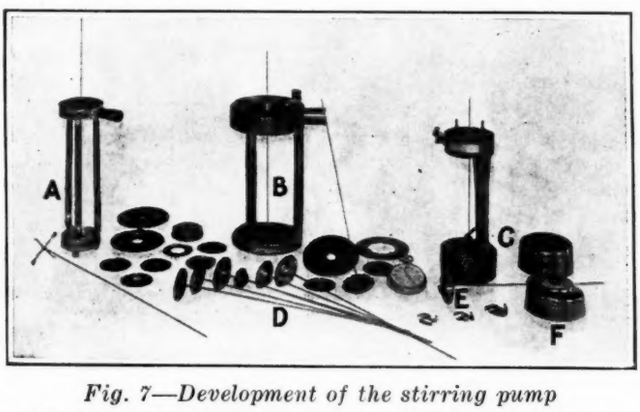


Fig. 7—Development of the stirring pump

The final design circulates 800 lb. per hour with a power consumption (at impeller) of only 0.1 watt.
A—First rough model. *B*—Model for studying forms of impellers and diffusion rings. *C*—Model found suitable for final use. *D*—Impellers tested in model *B*. *E*—Double impeller for model *C*. *F*—Parts of pump casing for model *C*.

to compile steam tables of much greater range and accuracy than any now available.

Great credit is due Messrs. Osborne and Stimson for their work in developing the method and apparatus for their important part of the A.S.M.E. Steam Research program. Their work affords an excellent example of the patience and skill with which American scientists are now attacking problems of fundamental importance.

Another article will tell of the work being carried on by Dr. Keyes, Taylor and Smith at the Massachusetts Institute of Technology.

The First World Power Conference

Engineers Study the Fuel Problem of the Present and Future—Speakers Advocate Low-Temperature Distillation—Pulverized Coal Arouses Discussion —Alcohol Called a Fuel of the Future

THE first meeting of the First World Power Conference as reported in *Power*, July 29, was occupied by discussion on the water power and fuel resources of the world. Other meetings were devoted to problems of steam generation, reports of which appeared in the Aug. 3 issue of *Power*. Of equal significance were the meetings covering the preparation of fuel during which attention was turned to low-temperature carbonization, coal distillation, coke-oven practice, peat and power alcohol.

Fuel Preparation Holds Engineers' Attention

ON THURSDAY, July 3, one of the sections, Dr. D. S. Jacobus presiding, devoted its attention to the subject of fuel preparations.

Prof. Henry E. Armstrong, Great Britain, discussed the treatments of coal with special reference to low-temperature carbonization. Public opinion will soon force the use of smokeless fuel and the recovery of byproducts. Attempts to date in this connection have not demonstrated a complete comprehensive commercial solution of the problem. It can only be through closer co-operation of the engineer and the chemist that the real fuel conservation of the future may be expected. It is of primary importance that this smokeless fuel must be produced in a compact easily combustible form which will stand reasonably rough handling in shipment for domestic and industrial fuel. The removal of dirt, ash and paper must be carefully studied. The manner of carbonization will depend on the kind of coal available.

A general view of the fuel situation in Sweden, mainly statistical in character, was given by Dr. A. F. Enstrom in his paper, "The Preparation of Fuels in Sweden." There are no coals mined in Sweden, but they have available large quantities of water power as well as enormous resources of wood, peat and oil shales. Considerable research has been carried on in Sweden regarding peat and oil shale, but little results of a practical nature have ensued to date. Sweden produces no oil, both her requirements of coal and oil being supplied entirely from abroad. Vast quantities of alcohol produced from waste products of pulp and paper mills are being used for power purposes, and there is a steady increased use of liquid fuel for motor-car service.

Charcoal Producer for Automobiles

In answer to inquiries concerning the charcoal producer system for automobile power, which was introduced and is now being somewhat extensively used in France and Austria, M. Brunschweig, of the French Department of Mines, stated that the principal difficulty of the so-called Imbert system of small charcoal gas producers has been in the purification of the gas, but that the difficulties had largely been overcome by a system of purification which he described.

Ing. Osker Taussig, in further discussion said that a very simple and foolproof apparatus, used mostly for heavy automobile trucks, had been worked out and was in extensive operation in Austria. It had not proved commercially applicable to passenger automobiles on account of the weight of apparatus necessary. There is a need of a new system for producing charcoal on a medium or large scale, as the present-scale production made charcoal too expensive for this small-producer application.

A most interesting paper on the conversion of coal into oils was presented by Dr. Franz Fischer, of Germany, who described the process of coal distillation which had been developed at the Kaiser Wilhelm Institute. It can never be hoped to convert all of any coal into oil, as would be evident by consideration of the carbon hydrogen ratio. However, it is to be expected of the future that much higher oil returns than have ever been obtained from distillation will be obtained through synthesizing. There is immense interest in the suggestion that conversion of coal into oil offers a third possibility for the efficient combustion of coal for the future beyond those already recognized in its use in solid or pulverized form.

The European industries apparently make more use of the facilities of the technical schools than do manufacturers of the United States. Prof. Hugo Strache outlined the work done in the Technical College of Vienna, Austria. To this school industrial concerns turn when desiring to have new processes worked out. Each year lectures are held for engineers engaged in industrial work, the course covering the treating of fuels and byproduct recovery.

Interest in the Vergius process which had been developed in Germany was expressed by one delegate, but it is understood that this process has so far only been developed commercially to apply to low-grade oils and is still in somewhat of an experimental state in its application to solid fuels.

Low-Temperature Carbonization Worth While

Low-temperature carbonization together with the results of several years of research by the Coal Research Board of England, was dealt with by Dr. C. H. Lander. Low-temperature carbonization could only be tested out ultimately on a commercial scale, as the laboratory tests do not in every case lend themselves to translation to commercial-scale size. Lack of appreciation of this fact has resulted in the expenditure of enormous sums of money without practical result. Study of the oils obtained from low-temperature carbonization should be made in order that they might be most efficiently and economically utilized.

Dr. D. S. Jacobus (U. S. A.) felt that the days of raw coal were numbered, but that complete economic success in the distillation of coal on a commercial scale has not yet been demonstrated.

That it was the function of the mine operator to produce a clean shipable coal was stressed by Sir Richard Redmayne. The operator must approach

the problem both from the domestic side and the power-generation side, in inspecting his output. The percentage of dirt shipped with coal doubled during the war, but coal is now coming out cleaner on account of the lessened demand. He stated that purchase coal on an analysis basis, such as is being done more and more in the United States, will produce cleaner coal and will result in good not only to the consumer, but also to the producer.

Great Britain, so Doctor Leonard Harvey felt, has more or less left the subject of pulverized coal to America, but low-temperature distillation can be successfully combined on a commercial scale with the use of pulverized fuel. He suggested the sale of gas distilled from low-temperature distillation plants or coke ovens, to municipalities for domestic and industrial service. There is a huge domestic market for a smokeless fuel that will stand handling, and even the dust from low-temperature carbonization processes could be very effectively utilized in pulverized-fuel furnaces. However, the difficulties of the high initial cost of vertical retort plants and the inadmittency of their operation which present economic conditions necessitates are obstacles. Mention was made of the Ford continuous-retort low-temperature carbonizing plants at Windsor, which have been followed with exceptional interest in England.

Engineers are well aware of the economic advantages of byproduct coke-oven recovery, low temperature carbonization, etc., but George Orrok, (U. S. A.) expressed the thought that before byproduct recovery became economically feasible it would be necessary that the load factor on such plants be increased from its present 30 or 35 per cent to 45 or 50 per cent. He pointed out that the market for many of the byproducts of carbonization was very unstable; in fact, it usually proves cheaper to burn the tar under the boilers than to take chances on a widely fluctuating market. Low-temperature coke breeze will not stand storage, and the alternative for a power plant using low-temperature distillation methods would be to have part of their boilers equipped for pulverized coal and part with stokers for burning solid fuel. At the present prices for gasoline in the United States, low-temperature oils stood little chance. B. F. Haanel (Canada) gave a further dissertation on Canada's resources and particularly referred to her efforts toward the utilization of her low-grade fuels. By adoption of the Hood Odell process suggested by the United States Bureau of Mines they had found themselves able to produce at the rate of 10 tons per hour, 25 per cent moisture peat at a price of $3.50 per ton.

Fuel Preparation Discussion Continued at Friday Session

THE meeting on Friday morning on the preparation of fuels was held under the chairmanship of Ing. Osker Taussig, of Austria. He referred particularly to the subjects of carbonization of fuel and the recovery of byproducts and emphasized that the proper place to clean coal was at the bottom of the mine, pointing out that by reason of the scarcity of fuels in Austria as now constituted, fuel and fuel costs must be saved all the way from the mine to and through the power plant.

About half of the morning was given over to the answering of questions that had been previously left unanswered, on the use of carbonized coal. A. E. Douglas, of the Fuller Engineering Co., consented to answer questions presented by any of the delegates interested in pulverized coal; his replies to the various questions are epitomized as follows:

The cost of preparing coal varies considerably on account of the following: (1) Hardness as well as ash content of coal; (2) percentage of moisture in coal as received; (3) cost of labor and cost of power.

Pulverizing costs of a number of modern plants have been averaged with the following results:

	Soft or Bituminous Coal	Anthracite or High Ash Coals
Capacity 100 tons per day, cents	45	63
Capacity 150 tons per day, cents	41	55
Capacity 200 tons per day, cents	40	53
Capacity 400 tons per day, cents	36	40
Capacity 500 tons per day, cents	34	45
Capacity 1,000 tons per day, cents	31.5	43
Handling from cars to furnaces	Kw.-Hr. 15 to 17	Kw.-Hr. 19 to 27

These costs do not include fixed charges such as interest and depreciation on the equipment, but do include labor, repairs, operating materials, power and supervision.

To substantiate these figures, the cost at the Lakeside plant of the Milwaukee Electric Railway & Light Co. was stated to be 17 kw.-hr. per ton of coal, while the cost is 32 cents per ton of coal; this plant uses more than 1,000 tons of coal per day.

The principal difference between the anthracite and bituminous costs is due to increased repairs to the pulverizing equipment and the higher power required for pulverizing; drying, labor and general operating costs are the same in each case.

The storing of pulverized coal is being done without any difficulty in hundreds of plants, and no trouble will be experienced from storing coal in pulverized form if the following provisions are made: (1) If properly dried and dried at a proper temperature; (2) if stored in properly designed bins, where the entire mass of coal will pass through the bin uniformly.

Slopes or hoppers should not be under 70 deg. Most of the difficulty in this respect has been from using flat-hoppered bins, where much of the coal has laid dormant for weeks or months, finally firing from spontaneous combustion.

Pulverized Coal System Handles Mine Waste

Such companies as the United States Steel Corporation, Ford Motor Co., Pacific Coast Coal Co., Susquehanna Collieries Co. and others are using pulverized coal at their mines, utilizing the smalls or waste sizes. In this way thousands of tons of commercial sizes have been released for the market, formerly consumed by the collieries in their own plants.

A matter often misunderstood by engineers investigating pulverized fuel, is that the cost of preparation cannot be considered as an added cost over that required in a stoker plant. In large pulverized-coal plants, the total cost of preparation is little, if any, higher than the actual handling charges of the coal, including the power and repairs on stokers, forced draft, fans, and coal-handling equipment in stoker plants.

It was stated that the heating of public buildings had been done with pulverized fuel in Seattle, but the cost of delivery was high. A central pulverizing company in Chicago had been formed to distribute pulver-

ized fuel to apartment houses in steel drums. Each drum is merely opened, turned upside down and fitted into the burners, and this system has proved reasonably successful. That there were some plants too small to consider the use of pulverized coal is admitted by all, but any plant of twenty to thirty tons per day can be effectively served by the unit pulverizer system.

Pulverizing Lignite

B. F. Haanel (Canada) claimed that the real field for pulverized fuel was in the use of low-grade fuels and particularly in industrial plants working intermittently. He referred to the enormous stand-by losses in stoker plants working intermittently and referred to the better control with pulverized fuel. For continuous operative plants there should be little difference in efficiency between stoker and pulverized-fuel installation. The Hydro-Electric Commission of Ontario is even now considering the question whether stokers or pulverized fuel should be installed at the new 100,000-kw. steam reserve plant which it is planning. With the intermittent operation that will prevail during the first few years of the life of this plant, there is no doubt that pulverized fuel would pay; the Saskatchewan lignites undoubtedly burned best in pulverized form, and the natural disintegration and great friability of these lignites should insure lost cost and pulverization.

World's Peat Supply

It was shown in a paper by Prof. Pierce F. Purcell, of the British Fuel Research Board, that definite progress is being made in the utilization of peat as fuel. The world's peat deposits were stated to exceed 200,000 square miles in area and to be capable of producing an amount of standard peat fuel equivalent to 75,000 million tons of coal. In Ireland nearly 15 per cent of the surface area of the country is covered by peat, and peat deposits provide over 43 per cent of the fuel requirements of Ireland. Frequent attempts have been made during the last quarter of a century, to eliminate or partly eliminate, the moisture content of peat by processes based on electrical osmosis, but so far commercial success has not been attained. Peat can be made to yield chemical compounds which add to the value of the material without affecting its value as fuel. These byproducts include powerful antiseptics and ammonia. In Germany, owing to post-war conditions in the Ruhr, strong efforts have been made to develop the use of peat and lignite. The maximum output recorded in Germany for a single year is 3,000,000 tons, whereas the Irish output has reached a total of 7,000,000 tons and that of Russia 10,000,000 tons.

A representative of Sweden expressed the opinion that Professor Purcell's estimates of the world's peat supply could be doubled. Reference was made to the Canadian Peat Research, which has tried mechanical pressing, artificial drying and even carbonizing, and finally disregarded all the chemical processes and adopted air drying only. The Hood-Odell process equipment, installed by the Canadian Department of Mines, which turned out ten tons of dried peat per hour for twenty-hour days at $3.50 per ton, was mentioned.

Professor Van Iterson (Holland) said that his country considered peat not as an inferior fuel, but as a superior fuel. Peat is the oldest fuel used in Holland, exceedingly satisfactory and successful results being obtained in its use.

Power Alcohol a Subject of Discussion

M. C. THOMPSEN, of Sweden, presided at the meeting on power and other sources on Friday afternoon, July 4.

He pointed out that the vast majority of power from solid, liquid and gaseous fuels, could be traced back to the sun. It was the purpose of that meeting to consider the more unusual sources of power, such as alcohol, wind, power utilization of the earth's heat, etc. He referred to the possibilities for greater utilization of tidal power, and spoke of the ten-kilowatt plant that had been installed in California, and a much larger plant now under contemplation in Newfoundland. There are great economic difficulties to be overcome in utilizing wind and tidal power, but these are on the way to practical solution. Reference was made to the possibility of direct utilization of the heat of the sun's rays and to the use of forms of power not directly traceable to the sun, such as the earth's heat, to be covered by Prince Conti, of Italy, in the description of the Lardarello low-pressure steam plant. There are possibilities for the future in the research work now being conducted on the liberation of atomic energy.

Discussing alcohol as fuel, Sir Charles H. Bedford stated that in many parts of the world active production or experimental investigation of the possibilities of producing power alcohol is being carried on, from raw materials offering the most favorable economic conditions in the particular area. Molasses, maize, sweet potatoes, flax pulp, cassava and nipah palm, are chiefly the bases employed.

Alcohol a Future Fuel

There are innumerable patented mixtures with varying amounts of alcohol in their compositions, but perhaps the three best-known fuels are Alcogas, Discol and Natalite. These have been manufactured for some time in fair amounts and have been used successfully.

Natalite is a complete substitute for petrol. In this it differs from most other alcohol fuels. It is self-contained, that is to say, it is essentially a mixture of alcohol and ether, the ether being easily and cheaply manufactured from alcohol. Small amounts of other substances are added to conform to the excise regulations which require all power alcohol to be denatured or rendered unfit to drink, and for other special purposes.

For the time being it is not expected nor is it desired that alcohol should replace petrol entirely as a fuel for motor cars, etc., and it would be unwise to think that a desirable object. It must, clearly, for some time yet, be developed in conjunction with petrol, and in this way conserve the world's petroleum resources. Bearing this in mind, and by reason of the fact that alcohol can be produced cheaply in almost any part of the world and can provide an excellent fuel at a price that should not materially increase, it necessarily follows that it must prove to be an extremely valuable factor in promoting the development of the British Empire.

The meeting closed with a description of the Lardarello Natural Steam Power Plant by Prince Erero Ginori Conti, of Italy, who stated that Larderello, the better known of the group of Soffioni, or Boric-Acid Steam Springs, in Italy, was so called because of the

founders of the Tuscan boratic industries, F. De Larderel, who in 1818 started manufacturing boric acid from these springs by concentrating the solutions by means of natural heat from the well. Finally, the feasibility of utilizing the natural steam as a means of generating mechanical and electric power was taken up in the beginning of 1904, when Prince Conti, then general manager of the Larderello Works, first attempted the use of natural steam with a small engine.

Present in this natural steam are considerable volumes of gases that have a serious effect on the metal of the engine. However, the result was quite satisfactory, and for the experiments carried on in 1905 they used a larger engine of about 20 hp. driving a dynamo, this engine working practically without interruption for over ten years. In 1912 a limited company was formed, and a 250-kw. steam turbo-generator was installed in 1914. This plant was increased until it was finally composed of three turbo units of 2,500 kilowatts rating each.

The direct use of natural steam through the turbines was not feasible both because of the acid and the low pressure. It was then necessary to use natural steam as a means of producing pure steam at a higher pressure for feeding the turbines. The problem was finally solved by means of a very simple apparatus which for want of a better name can be styled a "depurator." The steam issued from this apparatus contained only a slight portion of the original quality of the gas and can therefore be used for feeding the turbine. Pure or secondary steam is generated at a pressure of 1½ atmospheres, absolute. The condensers were originally of the surface type, but have since been modified and now operate as jet condensers, the trouble with the tubes thereby being eliminated. The Larderello plant operates in parallel with hydro-electric plants on the same system with perfect satisfaction. It was predicted that finally all such natural steam supplies will be used, although the number of such localities is not great.

The Gas Industry

CONSIDERATIONS involved in the gas industry were particularly referred to in the meeting on Monday, July 7. D. Milne Watson, Great Britain, who presided over the meeting, quoted some statistics that threw light on the magnitude of the gas industry in Great Britain. He reminded the Conference that gas undertakings used 16,000,000 tons of coal in a year and 46,000,000 gallons of oil.

That cheapness of coal led to this valuable fuel being wasted was claimed by Sir Arthur Duckham, Great Britain. If the returns from all power plants were examined, it would be found that less than 10 per cent of the potential energy of the coal was translated into useful work. Oil could never replace coal, for supplies were limited and oil and its products were so essential for other than industrial requirements that there was no prospect of this fuel being available at a sufficiently low price to serve the general means of industry. One method of using coal which gave a higher efficiency, was by conversion into pulverized fuel in association with the recovery of the gas and oil contents. This would appear to be the proper method of raising steam for the generation of electricity in bulk, the gaseous products being turned over to the gas undertakings for distribution. An alternative method was for the gas industry to treat the fuel, recover the byproducts and deliver the residue in the form of gas or coke to electricity supply stations.

The work of the British Fuel Research Board, Dr. C. H. Lander stated, indicated that an average yield of 15 gal. of oil could be obtained from every ton of coal carbonized on the low-temperature principle. There were many difficulties to be overcome in producing an oil suitable for marine service, but promising experiments were now in progress.

Gordon Adam, Great Britain, advocated the installation by all the gas works of by-recovery plants for the recovery of benzole. If this were done the annual benzole production could be increased by 27,000,000 gal. and the total production from gas works and coke-oven plants brought up to from 45,000,000 to 50,000,000 gallons.

A strong appeal for a governmental co-ordinating body in England to co-ordinate available fuel supplies with a view toward maximum conservation was made.

Mr. David Brownlie, of England, precipitated a rather interesting discussion with which he defied the gas industry to prove a greater heating value purchaseable per monetary unit by the gas consumer as compared with the coal consumer. He arraigned the gas industry for not paying greater attention to low-temperature carbonization and the possibilities of pulverized fuel. Instead of the gas industry being a very efficient industry, he thought on the whole it was a very inefficient manner of utilization of coal. This precipitated an attack by the gas interests on pulverized coal and low-temperature carbonization, the advantages of both being overrated, so it was declared.

In regard to the trouble with the deposition of ash and unburnt carbon in American pulverized-fuel installations, H. W. Brooks, Bureau of Mines, referred to correspondence with municipal smoke inspectors in Milwaukee, Wisconsin and Cleveland, Ohio, who had stated that no appreciable deposition of ash or unburnt carbon was apparent, although careful search for the same had been made at the instigation of persons not in sympathy with the use of pulverized fuel. A matter of insurance only, the Cottrell electric precipitation method had been installed at the Trenton Channel Plant of the Detroit Edison Co., but this equipment was rather expensive and probably unnecessary. With the tight system high stacks and properly regulated tuyeres there is slight excuse for depositions either of ash or unburnt carbon. Such ash as is emitted from the stacks, is emitted in the form of a fine palpable dust which is deposited into the atmosphere with such degree of dilution that the degree of deposition is not appreciable or worthy of consideration.

Professor Burstall, in his paper on "The Gas Engine," stated that he felt that gas-engine design of the future must be lighter and stronger than in the past. The opinion was expressed that the gas turbine would always be inefficient in comparison with the reciprocating internal-combustion engine; first, because it is theoretically impossible to get high efficiencies of compression or low gas temperatures in explosion turbines. In this opinion he was strongly supported by Dean Chandler.

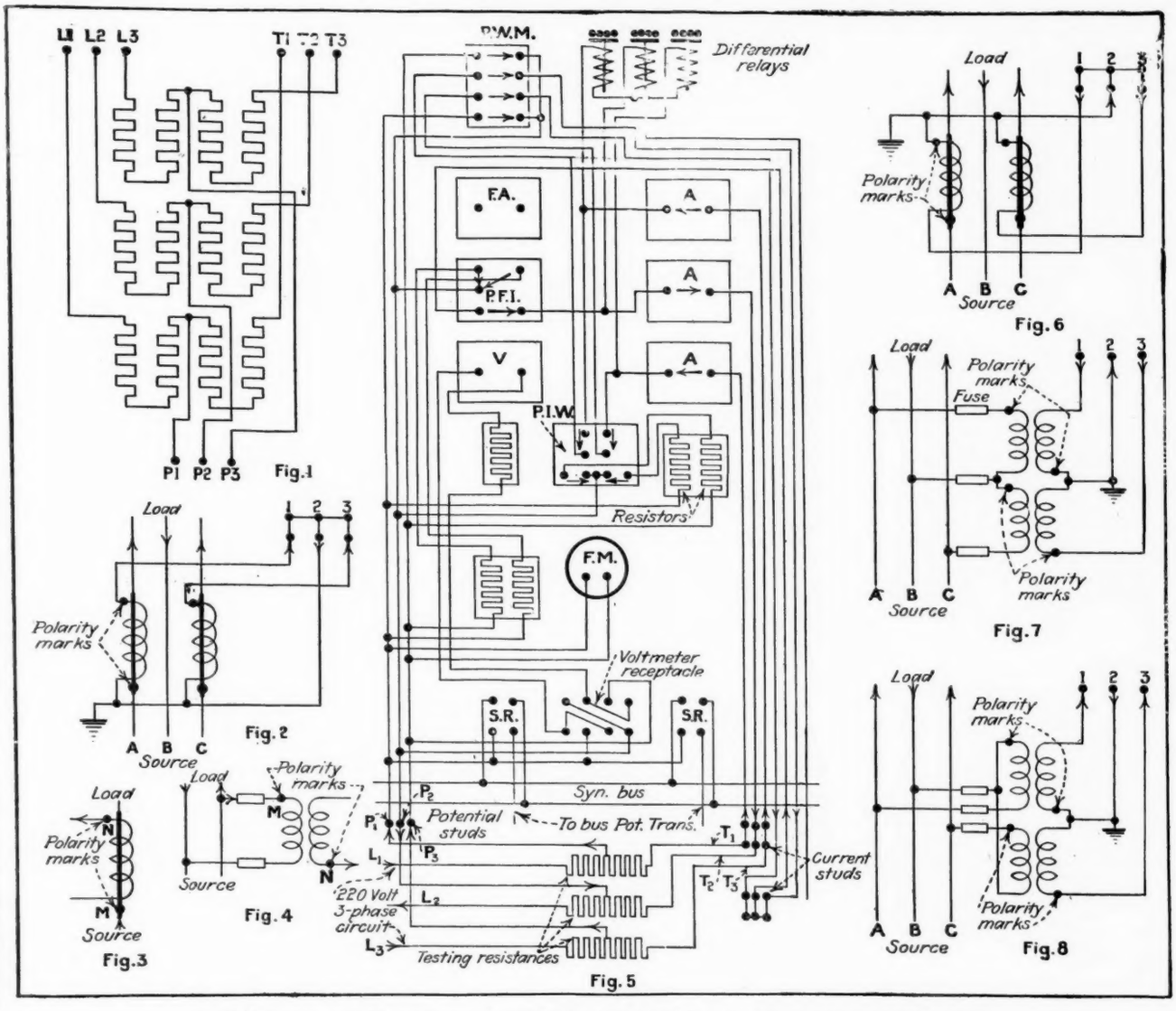
Toward the latter part of the meeting an exceptionally strong plea was made by several of the delegates for greater activity in fuel research. It is obvious that in order to know how to conserve fuel supply, it is essential that we know definitely, thoroughly and comprehensively, just what we are burning.

Checking Switchboard-Instrument Connections

By RALPH BROWN

EVEN when guided by a diagram of connections, it is not unusual for workmen to connect switchboard instruments incorrectly, particularly wattmeters and power-factor indicators. It is therefore necessary that all instrument wiring be checked by tracing each conductor and by ringing out each circuit before being energized from the instrument transformers. In addition to such checking it is well to make an over-all test by connecting the wiring to a low-voltage polyphase circuit, for incorrect connections, or defective instruments will thereby be disclosed.

Since the standard voltage for the potential coils of instruments intended for connection to potential transformers is approximately 100 volts, resistances other than those supplied with the instruments are not required for testing purposes if energy can be obtained from a polyphase 100- or 120-volt circuit. Remembering that the impedances of the current coils are low, it is evident that the voltage applied thereto during the over-all test must likewise be low. By the use of suitable resistances any desired current can be obtained, but one value, such as 3.5 amperes, is sufficient. The standard current for instruments provided with current coils being 5 amperes, 3.5 will give a good deflection.



Figs. 1 to 8—Diagrams of methods for checking instrument connections

Fig. 1—Diagram of testing resistance. Figs. 2 and 6—Indicate relation between primary and secondary current in current transformers. Figs. 3 and 4—Polarity markings on instrument transformers. Fig. 5—Connections for testing switchboard meters. Figs. 7 and 8—Indicating relation between primary and secondary current in potential transformers. *A*, alternator's ammeters; *F.A.*, field ammeter; *F.M.*, frequency meter; *P. F. I.*, power factor indicator; *P.I.W.*, polyphase indicating wattmeter; *P.W.M.*, polyphase watt-hour meter; *S.R.*, synchronizing-plug receptacles; *V*, voltmeter.

Fig. 1 shows how resistances were grouped to test the instrument connections of a generator panel where it was necessary to obtain testing energy from a three-phase 220-volt circuit. Twelve coils, each consisting of 20 ft. of No. 18 Nichrome wire and having a resistance of 9 ohms, were required. The coils were supported between two pieces of transite, the top piece being provided with 9 terminals, marked as shown in Fig. 1. Since the resistance per group was 36 ohms, there being 4 coils connected between terminals L_1-T_1, L_2-T_2, and L_3T_3 the maximum current that could be obtained would be approximately $\frac{220 \times 0.58}{36} = 3.6$ amperes. Owing to the impedances of the current coils the indicated current was but 2.9 amperes. Voltage for the potential circuits was obtained from terminals P_1, P_2 and P_3, connected to the midpoint of each group of resistance coils.

Connections for Testing Panel

Fig. 5 is a diagram of the instrument connections on the panel tested. The instantaneous directions of the current are indicated by the arrows, these directions being reversed when the instruments are energized through the potential and current transformers. Terminals P_1, P_2 and P_3 are connected to the potential studs, as shown in Fig. 5. Terminals T_1, T_2 and T_3 are connected to the current studs on the panel, and L_1, L_2 and L_3 are connected to the line. The differential relays, which are star-connected at a point between the ammeters and the indicating wattmeter, shunt about ¼ ampere from all devices beyond the ammeters. Therefore, even though the power factor is nearly unity, the watt-hour meter and wattmeter cannot be checked by the ammeter and voltmeter indications. With the differential relays disconnected, the power indicated by the wattmeter, and integrated by the watt-hour meter, should closely approximate the value obtained by multiplying the voltmeter and ammeter readings by the correct constants.

If correctly connected, when testing energy is applied the three ammeters should read alike, in this case at $\frac{2.9}{5} = 0.58$ of full scale deflection, and the speed of the watt-hour meter disk should be proportional to the power indicated by the indicating wattmeter. The power-factor indicator should read approximately 0.99, lag, the frequency of the testing current should be shown on the frequency meter, and the voltmeter should indicate nearly 100 volts when connected, by means of the plug, across each phase.

Obtaining Readings on the Meters

This over-all test is not intended to determine the correctness of the differential relay or synchronizing connections, but it will disclose any error in the instrument connections by causing incorrect indications. The watt-hour meter pointers will be moved away from their initial positions during the test, but they may be easily reset by reversing the direction of current through either the potential or current coils, thereby reversing the disk's rotation.

Depending upon the manner in which the groups of current and potential transformers are connected, negative readings on the wattmeter may be obtained when testing energy is applied. While this condition can be corrected by reversing the direction of current through either the potential or current coils of the wattmeter and watt-hour meter, it is desirable that the connections be arranged so that the wiring need not be changed for the purpose of testing. Changes in connections will not be necessary if the instrument transformers are so grouped that the instantaneous directions of current at the terminals are relatively the same; that is, from the transformers to the instruments in the center wires, returning through the two outside wires, or vice versa.

If a group of current transformers, having polarities as shown, are connected as in Fig. 2, with the common, and usually grounded, wire on the source side, the instantaneous directions of current flow will be from the current transformers through the outside wires to the instruments, the center wire forming the return path. The instantaneous directions of current in the secondary wires, 1, 2, 3, correspond to the standard directions for current in the main conductors, *A*, *B* and *C*, which is from the source to the load through the two outside wires.

Polarity of Transformer Connections

In Fig. 6 the current transformer secondaries are grounded on the load side, this causing the instantaneous directions to be toward the instruments in the center wire, returning through the outside wires. Fig. 7 shows the usual method of connecting two potential transformers to a three-phase circuit. In this diagram the instantaneous direction of current flow is out the center wire and toward the transformers in the two outside wires. In Fig. 8 the potential transformers are so connected that current flows out the two outside wires, returning to the transformers through the center wire. The instruments can be connected to read correctly by using any transformer combination indicated in Figs. 2, 6, 7 and 8, but to make changes in connections for testing unnecessary potential and current directions should be relatively the same. No change for testing need be made if the transformers energizing a group of instruments are connected as shown in Fig. 2 and Fig. 8 or according to Fig. 6 and Fig. 7.

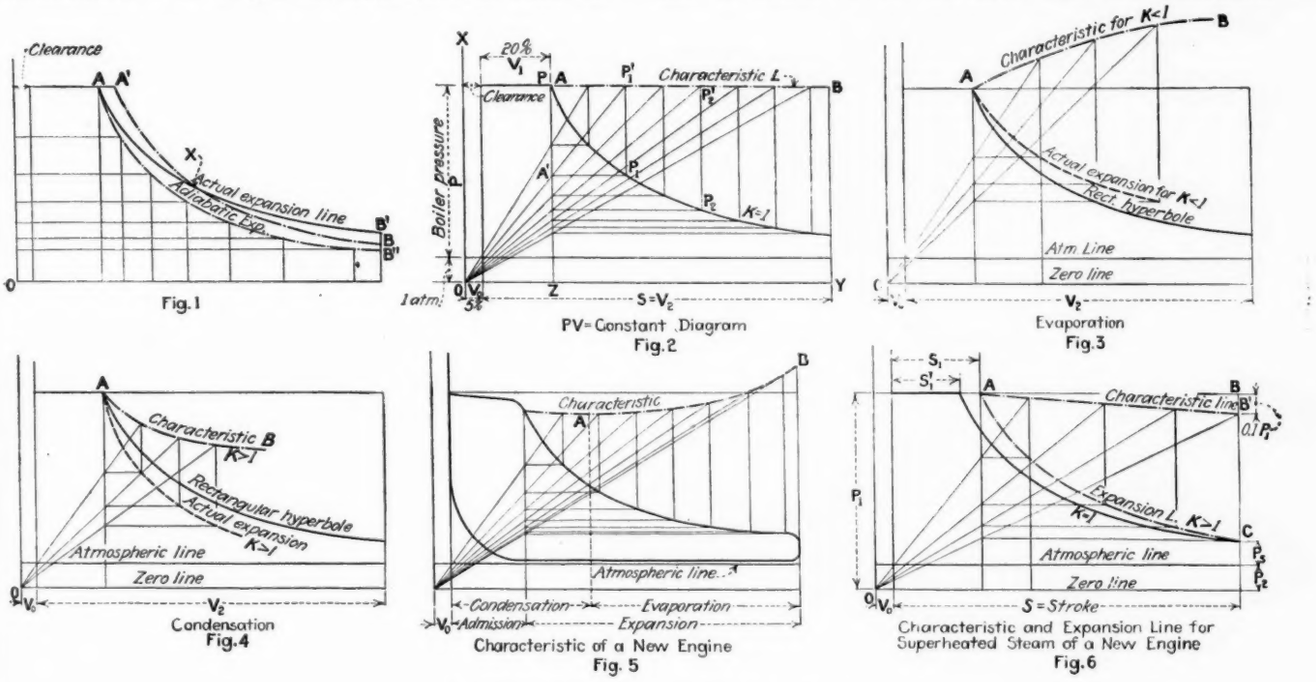
Fig. 3 shows the relation existing between the primary and secondary currents of a current transformer having the polarity indicated. Current entering polarity mark *M* flows out at *N*. In Fig. 4 the instantaneous directions of current in the primary and secondary of a potential transformer having a polarity as indicated are shown. Account must be taken of the polarities of instrument transformers if switchboard connections are to be correctly made. Connections between the instrument transformers and the terminal studs on the switchboard panel are usually made by conductors identified by a colored braid or metal tags.

A bad practice in air-compressor operation is to put the air-discharge pipes through the intake duct. This serves directly to defeat the gain of the cool duct, because the hot discharge pipe heats the incoming air. On one such installation the incoming air was heated 6 deg. F. by the presence of the discharge pipe in the intake duct. In this case there was a direct throwing away of about 1½ per cent of power, which amounted to throwing away 11½ lb. of coal every time 1,000 lb. was shoveled into the furnace, all summer and all winter, day in and day out. In estimating such a heating loss a rough figure is 1 per cent loss for each 5 deg. F. intake-temperature rise.

Study of Indicator Diagrams Made Easy

By E. K. BENEDEK

EVEN though engineers are inclined, when taking steam-engine indicator diagrams, to assume that as long as the expansion line looks smooth, all is well with it, and concern themselves solely with the timing of the several valve positions, there is an easy method of examining the expansion line. The smoothness of this line does not prove that the engine is performing satisfactorily, for there can be a large amount of valve or piston leakage and excessive cylinder condensation even though the expansion line looks perfect. For these reasons a simple but little known method of diagram analysis will be outlined.



Construction of characteristic lines

In the ideal engine, where there is no loss of heat by the steam to the cylinder walls or absorption from the walls during the latter part of the expansion stroke, the expansion line should be adiabatic, in which the equation $PV^{1.135} = constant$ applies. On the other hand, during expansion in a reciprocating engine there is an essential heat transfer between steam and cylinder wall, and the consequence of it is the deflection of the actual expansion line from the adiabatic line.

It is evident that during the admission period and during a certain part of expansion there is a heat transfer from the steam to the cooler cylinder wall, which brings about the condensation of a certain quantity of steam. The consequence of this condensation is that at the same volume the pressure will be less than it would be if there were no condensation. Therefore the actual expansion during the period of condensation will be under the adiabatic line.

On the other hand, during the rest of the expansion the cylinder wall gives heat to the steam, which heat will evaporate a certain quantity of the condensed water, and there is more steam in the cylinder than there would have been if no heat transfer had taken place between the cylinder wall and the steam. The result is that the volume of steam in the cylinder at cutoff is A in Fig. 1 and not A'. The actual expansion line AB begins at A and is below the theoretical adiabatic $A'B$ until the re-evaporation causes the volume of steam to be increased over the theoretical amount; this takes place at X, and from this point to the end of the stroke the actual curve rises above the adiabatic. It is customary to construct the adiabatic to draw it through the cutoff point A, causing the actual curve to rise above the adiabatic throughout its length. This deflection of the actual expansion line from the adiabatic makes it necessary to find a better approximation curve to represent the actual expansion curve.

Careful experiments have pointed out that a diagram representative of conditions in a high-grade engine can be obtained under the assumption that the quantity of working steam is the same through the whole expansion. The deviation of the expansion line of this diagram from actual expansion lines of saturated steam is practically negligible, and therefore this curve has been selected as a design diagram for new engines and called the "Constant Quantity Diagram." The equation for this constant quantity diagram is $PV^{1.004} = Constant$, which gives values so close to those given by the equation $PV = Constant$ that the latter is used.

The curve represented by $PV = Constant$ is above the adiabatic, and in reciprocating engines of one cylinder with 20 to 40 per cent cutoff the actual expansion curves follow this curve. While the construction of this rectangular hyperbole curve is familiar to everybody, it is shown in Fig. 2 in order to call attention to certain properties of this curve and give a physical interpretation of the construction.

Construction of Diagram

After having decided on cylinder dimensions, one can determine the volume V_2 and a certain per cent of this, V_o, as the clearance space. To the given steam conditions the admission pressure line is plotted. Assuming 20 per cent steam feed V_1, the construction shows how P, P_1 and P_2 correspond to one another. We must remember that the OY line is the zero line for pressure. The line AB between the cutoff volume line AZ and cylinder volume line BY is called the "characteristic line of constant quantity expansion," or the characteristic line of the rectangular hyperbole. In constructing the expansion curve, any line OP_1^1 is drawn from O; a perpendicular is dropped from P_1^1 and a horizontal line drawn from A', the point where OP_1^1 crosses the line AZ. The point P_1 where these two lines intersect is a point in the rectangular hyperbole through A.

Conversely, with a given expansion line the reverse process is followed, and by drawing lines from O through a number of points in the expansion line, the characteristic line, as AB in Fig. 2, is obtained. In the following we shall see that in most instances AB will not be a horizontal straight line, but a curve with a concave and convex curvature.

In order to point out that the straightness of the characteristic AB is only a special case of special cases, we must give a general explanation of general characteristics. The general equation for any steam expansion is $PV^k = Constant$. All these curves represented by this equation are called polytrops. A polytrop expansion curve is determined by a fixed value of K. We know that in the case of saturated steam the values of K are expressed by the equation $K = 1.035 + \frac{1}{10} X$, where X is the specific steam quality; for dry saturated steam $X = 1$ and $K = 1.135$. The exponent K is greater than, equal to or less than unity, according to the actual conditions. These three conditions must be discussed regarding the behavior of the characteristics corresponding to the case.

We have seen that $K = 1$ leads to the rectangular hyperbole $PV = Constant$, where the characteristic is a horizontal straight line AB. It means physically that the quantity of steam is relatively constant during the whole stroke, no condensation, no evaporation, no leakage from the cylinder cover into the cylinder taking place.

Re-evaporation Indication

When the pressure of actual expansion is larger than that of constant volume expansion, K must be less than one. In other words, when the expansion curve is above the $PV = Constant$, then K is less than 1 and the characteristic is above the horizontal straight line as shown by AB in Fig. 3. However, if the pressure at any volume is larger than that of the rectangular hyperbole, it means physically that new steam has been produced on account of heat transferred by the cylinder wall. The conclusion is that K, being less than unity, is physically equivalent to the evaporation in the cylinder, producing more steam and increasing the pressure above the pressure of constant quantity expansion; the characteristic is AB likewise increasing, and if the evaporation is high the rate of increase of characteristic is large.

If K is greater than unity, the expansion curve is below the rectangular hyperbole as shown on Fig. 4 and the characteristic AB has a decreasing tendency. This case corresponds to condensation, for if the steam condenses, the pressure drops down at the same volume and all pressures are below those of the rectangular hyperbole.

Characteristic Reveals Leakage

Where the characteristic curve has a horizontal tangent at point AB, Fig. 5, at this point of the stroke the amount of heat absorbed by the steam from the cylinder wall is just enough to replace the amount of heat converted into work, thereby keeping the quantity of steam constant. Between A and B the actual quantity of steam is increasing owing to the absorption of heat from the cylinder walls and steam evaporating part of the water on the walls. If the downward slope of the characteristic is relatively sharp, we are faced with untightness of piston rings, which permits the steam to escape through the piston rings into the other side of piston, causing the quantity of steam to be less. The expansion line, of course, falls below the $PV = Constant$ curve.

It must be emphasized that the equation $PV = Constant$, when applied to steam, has not by any means the same physical meaning as when applied to the ideal gases, where it is well known that the expansion must be isothermal. In steam engineering the equation is a practical result and expresses the actual expansion line of saturated steam. Furthermore, the equation here has a geometrical meaning and expresses the constant quantity expansion.

In the construction of the characteristic curve one starts with the determination of the zero pressure line, or vacuum line. The next step is to determine the clearance space in percentage of the given stroke, and the determination of the end of admission or cutoff.

Characteristic of Superheated Steam

In the case of superheated steam the construction of the characteristic of a given indicator diagram is the same. The slope tendency of the characteristic will be a decreasing one, as K is greater than unity in the case of superheated steam. At high superheat $K = 1.33$, whereas at moderate superheat it varies from 1.15 to 1.25. Knowing the properties of characteristics for the case of K is greater than 1, we can construct the expansion line for a new engine as follows: Having been given V_o and S, as in Fig. 6, the admission pressure P_1 and exhaust pressure P_2 at the end of the stroke, we add P_s to P_2. From C backward construct the rectangular hyperbole which will determine the admission S_1^1, and we make use of it by assuming the admission for the superheated steam S_1, and while the slope of superheated steam pressure line is greater than that of $PV = Constant$ curve, S_1 must be assumed greater than S_1^1 at B, a distance BB' is laid off equal to $0.1 P_1$ and the characteristics AB' is drawn as a straight line. By this characteristic we design the actual expansion curve, which should be ended in point C. If not, we have to change S_1 to cause the expansion line to strike C, several trials often being necessary.

An Argument for Steam Reserve

NO MORE convincing proof of the necessity for steam reserve to supplement hydro-electric power is afforded than the present power shortage in California, where an unprecedented drought has forced a twenty-five per cent curtailment in load, much to the inconvenience of many consumers. While New York State still leads in total hydro-electric output, if we exclude the large concentration of continuous power at Niagara, California ranks far ahead of the other states in the development of its water power. And, although interconnection has been carried out to a high degree on the Pacific Coast, it has failed to meet the present emergency because of the relatively small amount of steam reserve.

With fuel oil plentiful and relatively cheap in California, one is led to question why more steam plants have not been built in that section. It is true that additional steam capacity is now under construction, but it can hardly be completed in time to help out the present shortage which, it is predicted, will last until November.

This case should serve to impress upon those who are deliberating upon the question of purchasing or generating power for industrial purposes the desirability of looking into the continuity of supply as a factor of equal, if not greater, importance than the matter of rates. Furthermore, it should indicate to certain public men who are in the habit of preaching water-power development as the solution of our power problem, in affording a cheap and adequate supply, that they are viewing only one side of the case.

Increasing the Output of Diesel Engines

AT NORMAL output the amount of air in the cylinder of a Diesel engine is practically twice that needed to burn the fuel charge completely. It would seem that the air-to-fuel ratio could be decreased, giving an increased mean effective pressure and greater net power output. The difficulty lies in the inability of the fuel to mix with the entire air charge. This has been surmounted by a special air valve which forces a jet of air across the fuel spray and so gives an increased turbulence. A method practiced by many operators when load conditions force the engine to carry overrating is the raising of the injection air pressure to well over a thousand pounds. While this calls for a greater compressor horsepower, the higher air velocity does improve the mixing action in the cylinder. There is, of course, a limit to the results obtained, and in addition the increase in the heat stresses in the cylinder is by no means beneficial. The procedure is one to be followed only in case of an emergency.

Supercharging, or the admission of the air charge at a pressure somewhat above atmospheric, does not decrease the air-to-oil ratio, but, by augmenting the weight of air in the cylinder, permits the burning of a greater amount of fuel with no change in the air-to-oil ratio. A number of methods have been followed with success with European engines. In the two-stroke-cycle engine supercharging is easy of attainment, since by proper timing of the scavenging air valves, air at two to ten pounds gage can be admitted even after the exhaust ports are sealed. In fact, this is quite generally used at the present time, especially when the units are located at a high altitude.

The same idea can be carried out in a four-stroke-cycle engine by providing a low-pressure compressor, either of the blower or the reciprocating type. The chief alteration required is alteration of the cylinder clearance volume in order to keep the compression ratio as before. An increase in the cylinder length or decrease in the connecting-rod length is obviously necessary. The increase in horsepower output is far greater than the additional power needed to operate the blower. In fact, there is no reason why the exhaust gases should not be used in a suitable gas turbine driving a rotary air compressor, as has been developed for airplane service.

Supercharging should be more generally adopted, for it permits a greater output per unit cylinder volume, and in a general way engine construction costs are in direct ratio to the cylinder dimensions. While the heat stresses would be somewhat above those customary experiments indicate that they would not be excessive. The fuel consumption would be but slightly higher than at present, and this minute increase in operating charges would be more than offset by the lowering of the fixed charges.

In the opinion of many authorities the double-acting principle offers the greatest possibilities. While European firms have already built such units on a commercial scale, the engine is still in a more or less experimental stage in this country, although one company is now preparing to place a large double-acting engine on the market.

Effects of Pressure Change in Penstocks

AS LONG as water-power plants operated under low heads, the question of pressure changes in penstocks were of little moment. If the structure was made sufficiently strong to meet normal operating conditions, they were generally safe for any changes of pressure that might occur during operation. As heads of two and three hundred feet and higher came into general use with long penstocks connected to large modern units, the problem of preventing excessive pressure changes became a serious one. On some of the large units, in the penstock is a column of water hundreds of feet in length, weighing thousands of tons, moving when full load is on the turbine at ten to twelve feet per second. It is not an uncommon occurrence

in operation for the full rated load to be tripped off the turbine, in which case the mass of water in the penstock or pipe line must be brought to near rest in a period of time that will prevent excessive speed of the machine, which is usually about two or three seconds. On the other hand, it is not unusual for these units to be suddenly subjected to large increases of load, which may require that the turbine gates must open from near no-load to maximum-load position in a few seconds.

If the penstock is long, its profile can be of a shape where even a more dangerous condition may exist when the water is being accelerated than when it is retarded. The rise in pressure in penstocks due to retardation of flow is something that has been generally understood for a considerable period, and the theory has been well worked out by a number of eminent engineers. Conditions arising from acceleration of flow in penstocks and pipe lines have not been so well understood, or at least they have not been so well appreciated, as evidenced by some penstock and pipe-line failures. It is not only possible to create a vacuum in the penstock, but the water column may actually part and cause disastrous water hammer under certain combinations of sudden load increases and rejections, unless careful consideration is given to the shape of the penstock's profile.

Rises of pressure due to retardation of flow can be taken care of by the use of a relief valve, installed near the turbine, but for fall in pressure no such means are available. In the latter case the danger point does not exist at the turbine, but somewhere up along the penstock. If these conditions are to be prevented, the penstock must be designed so that its profile will be of such a form that no part of it will be under a vacuum with the allowable maximum rate of governing.

After a plant has been put into service, it is the province of the operating engineer to maintain conditions that will not endanger the equipment. As any decrease in a turbine's governing time will cause an increase in the fall and rise in penstock pressure, it is well to check the effects in medium- and high-head plants to prevent creating dangerous operating condition. In this issue S. Logan Kerr, in his article, "Fall in Pressure in Hydraulic-Turbine Penstocks Due to Acceleration of Flow," has reduced the problems of change of pressure in penstocks to a few simple calculations and the use of charts from which the final value can be read. Although the theory of these calculations is very involved the methods used have put the effects of water hammer in such form as to be readily applied by the average operator.

An Old Controversy Revived

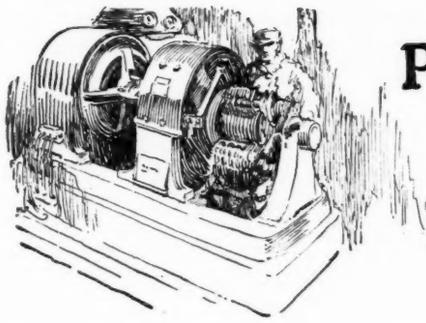
ONE of the earliest controversies in the electrical power industry was whether the transmission and distribution systems of the future should be direct or alternating current. In this country the direct-current system never made much headway except for three-wire low-voltage distribution in congested city districts, in small and medium-sized industrial plants and for railway service. Today even in many of the smaller industrial plants alternating current is being used. With the exception of a few railway systems all electric-power transmission at voltages above six hundred is done by alternating current.

In Europe this has not been so universally true as on the American continent. In the early eighties a system was developed for transmitting direct-current at three thousand volts, and two thousand volt direct-current railway systems were put into operation shortly thereafter in England. In continental Europe Thury developed his series system of direct-current power transmission, and it has been used to some extent for voltages up to one hundred thousand. As this system requires a large number of generators in series to produce the voltage for transmission and the same number of motors in series driving generators to step the voltage down for local distribution, it has never met with favor. In fact, the system is one of transmission and not of distribution. In later years, as the power systems in Europe have expanded, the tendency has been toward the use of alternating current as in this country.

At the British Empire Exposition the exhibiting of the "transverter," a device for converting high-voltage alternating current into direct current or vice versa has, particularly in Europe, done much to revive the old controversy of direct-current versus alternating-current transmission of electric power. This machine, which has been built in sizes up to two thousand kilowatts, is a step-up or a step-down static transformer combined with a number of commutators connected in series, the brushes of which are driven at synchronic speed. The sizes of this unit and the voltage, one hundred thousand, that it has been designed for, have created much interest in its possibilities.

If alternating-current had reached a limit as to transmission voltage and the industry was looking for some means of overcoming the difficulty, there might be more of an incentive to introduce other complications in power-transmission systems. The 220,000-volt alternating-current system will for a number of years to come meet all our requirements so far as long-distance transmission is concerned. Although such high voltage lines have characteristics that require special machines to rectify, this problem has been satisfactorily solved with comparatively simple equipment. Even where it is desirable to transmit power under ground at high voltages, the problem is being met in a fairly satisfactory manner. Cables are in operation on alternating-current voltages up to 66,000. Although the characteristics of these cables may not be all that is desirable, the future holds forth promising prospects for their improvement. So that here again developments would not seem to warrant the introduction of the complications of a direct-current machine. Although the transverter has been built of a size and operated at a voltage that would indicate that those who are developing it have confidence in its future, the size of the machine is far from being one that would fit into our modern transmission system. Nevertheless, the daring and initiative of the manufacturers must be admired.

The interest lately shown in automatic boiler-room control and its installation in a number of stations may be surprising in view of the antagonism shown the idea only a few years ago. Perhaps one reason for the change is a realization that such control is not designed to displace entirely the human element, but rather to serve the steam-making department of the plant in a capacity analogous to the governors on the prime movers, thus affording the operator greater freedom for supervision and individual adjustments when they are necessary.



Practical Ideas *from* Practical Men

How To Avoid Clinkers with Hand-Firing

There are many ways in which clinkers are formed, and by following a few simple methods of firing, their formation can be greatly reduced.

Clinkers are the result of melted ash, or ash that has been hot enough to lose its original shape and change to a thick liquid, which finally settles down to the grates, where it solidifies and forms slag or clinker. The most common ways of producing clinkers are as follows: (1) By raising the ash from the grates up into the fuel bed, where it is exposed to a high temperature. (2) Throwing a large quantity of coal on a bright spot in the fire bed. This bright spot is often a thin place where the draft has less resistance and is acting as a blow-torch which causes the coal to be in a soft state and, when a heavy charge is put on, is compressed to a solid mass through which air cannot pass, and hence a clinker is formed with unburned coal in it. (3) By burning rubbish or coal containing ash having a low fusing temperature in a fire with a hot burning coal.

The following simple rules should be memorized and applied in practice: First, keep ashes where they belong and do not mix them with the burning coal; second, do not throw a heavy charge of coal in one place, but spread it evenly; third, do not burn rubbish or a fuel with a low melting ash in a fire with a good grade of coal.

I have had considerable experience with clinkers and have found the following to be exceptionally beneficial in preventing them. When starting a fire, whether from kindling or a bank, first remove all ash and clinkers, then evenly spread the kindling or bank, as the case may be, over the grates. Then on this throw a small quantity of coal in sizes ranging from nut to egg until you have a good body of coals; then you may use any reasonable size of coal without breaking down the fire bed or choking the draft. With some classes of coal the small sizes or slack start better than the nut size, but if used, care must be exercised to spread the fuel well and in small quantities or the fire will be checked.

We have found the following practice to give excellent results when firing on tests where high economy was desired with as little smoke and clinkers as possible: Our furnaces are four feet wide, and we fire four times of one shovelful each, to cover the grates, each shovelful being spread evenly over one section of the grate, thus eliminating any damage to the fire bed by heavy charges of coal in one place. When there is not enough draft, we reduce the thickness of ash by shaking the grate or by using the slice bar, but are careful not to raise the ash up in the fire.

Assuming there is only good coal on hand, the following methods of banking will be found excellent practice: Shortly before shutting-down time, build one side of the fire thicker than usual, allowing the gases to be driven off and then charge it up again, continuing this until a strip about 18 in. wide and 3 ft. long is built up. The other side of the fire should be allowed to burn very thin. With this method you are ready to close off all dampers gradually in the last few minutes' running and be all through when the whistle blows, as the damper can be closed off without causing smoke.

In the morning all clinkers and ash should be first cleaned from the grate, then the bank of coke should be spread over the grate and broken up. The fire can then be built up gradually to the proper thickness. These simple suggestions are not all that could be said, but will serve as a great help if put into practice.

Winnipeg, Man., Canada. C. RYE.

Piston Rings Close in with Engine in Service

Wanting to make a slack piston finish the season, when the cylinder could be rebored and a new piston fitted, I put new rings on the piston and kept the engine in service. Although the rings were fitted properly and had plenty of "snap," when reboring time came about four months later, I found what I had never seen before. The thin tips of the eccentric piston rings had slipped one under the other and the rings had closed in till their outside diameter was even smaller than that of the worn piston. We have all seen rings gradually wear and open out till all the snap was gone, but to see them close in without any appreciable wear was entirely new to me.

Now, I knew that in order to close, their outside circumferences would have to lengthen while their inside circumferences remained stationary. That I figured could be done only by some process of hammering, as if they were being peened on their outer surfaces to lengthen them. On close examination of the cylinder wall I found evidence of such a hammering directly opposite the head-end port at the end of the piston-ring travel. There was plain evidence that the rings at steam admission had been thrown against the cylinder wall, and in this case that would amount to a little over 100,000 times per day, say, ten million times in all.

Now if we were to take a piston ring and hang it over the horn of an anvil and gently peen it, we would lengthen both inside and outside surfaces alike and the ring would not change its circle curve. But if we were to take the ring and hang it over our finger and then peen on the outside, using the inertia of the ring's weight to peen against, we would lengthen the outer surface only and the ring would close in to a smaller circle. So the conclusion we finally arrived at was that

in some way the slackness of the piston and the beveled side of the cylinder head counterbore projection which deflected the steam against the corner of the piston combined to give the admission this effect on the rings.

Vancouver, B. C. R. MANLY ORR.

Boiler Inspectors and Inspections

A great deal has been written in the technical press about boiler inspectors and inspection. Frequently, however, the writers lose sight of the fact that boiler-inspection service is to safeguard the boiler owners and general public from accident. Therefore, not enough can be said to improve this important branch of engineering service.

Frequently, a "monkey-wrench engineer" who, by several years of careful application and study, has been able to secure employment and a license as a boiler inspector, gets the erroneous impression that he has obtained all available information on this subject. It is for the benefit of the inspectors who "know it all" that this is written.

A boiler inspection, to be of value, must be thorough and complete. A boiler inspector, to give satisfactory service, must be accurate, observing and have good judgment. These qualities, however, are of little use unless the inspector has a thorough and practical knowledge of boiler construction and operation.

Before an inspector can know a boiler, it is necessary for him to obtain all construction data required on the standard data inspection report. Most inspectors are required by their employers to obtain this information at the first inspection. However, it has become the general practice of many of the younger inspectors recently entering this line of work, to use the data obtained by some other inspector rather than to broaden himself by obtaining his own data and making his own calculations, with the result that he cannot know the boilers he is inspecting as thoroughly as he should.

The actual inspection of boilers is important work but the inspector's duties do not end there. Unless he has the ability to gain the confidence and respect of the owner, engineer and fireman in the plants where he works, he is not satisfactorily filling his position. When this confidence is obtained, the inspector can obtain the history of the equipment which he is inspecting and also ascertain and judge the condition of the equipment in the light of the operating history of the boilers since his last inspection. In this manner he can advise regarding scale treatment, load conditions and major repairs in a much more effective manner.

Frequently, inspectors overlook the fact that plant operators are about their boilers every day, while the inspector sees them but a comparatively short time at long intervals. The best inspector can learn much from the operator.

When defects or conditions requiring attention, repair or change in operation are observed, the inspector must bring these conditions to the attention of the person in charge of the plant. Recommendations for changes must be practical and justified by the conditions if they are to be of value to anyone. These changes, to be thoroughly understood, should be discussed at length and suggestions from the operating force should be given careful consideration, after which the inspector will be in a position to give his definite approval or disapproval of the suggestions offered. If the inspector encounters an operating force who have no ideas regarding the repairs required, he certainly must be in a position to state the repairs and changes necessary without hesitation.

Summing up the foregoing, an inspector should have the following qualifications:

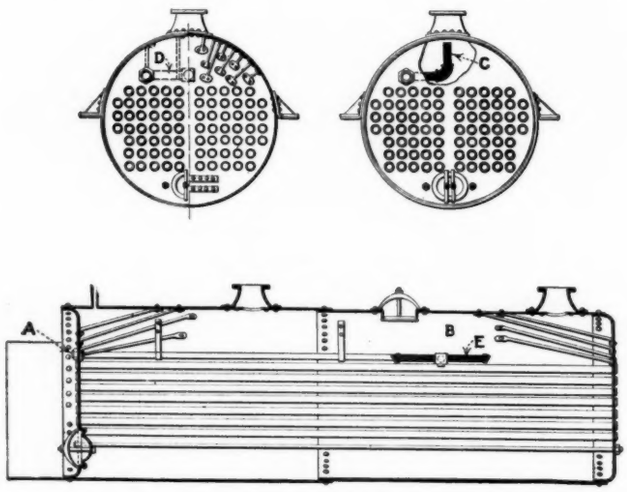
1. Sufficient practical experience in boiler operation and construction to understand the conditions that he meets.
2. Sufficient technical education to calculate correctly the strength of the boilers he inspects and to handle his correspondence and reports in a clear, concise and intelligent manner.
3. Sufficient mentality and perception to observe and analyze defective boiler conditions and determine their causes from the evidence at hand.
4. The ability to make practical suggestions and recommendations for repairs and operating procedure.
5. Last but not least, a whole lot of common sense.

Chicago, Ill. C. W. OLANDER.

Pressure Dropped When Feeding Boiler

After taking charge of a power plant where there are return-tubular boilers, I noticed that when feeding the boilers the pressure would fall excessively.

At the first opportunity I went through the boilers and the only cause I could find was the feed-water



Arrangement of feed-water pipe in the boiler

pipe discharge. The pipes entered the boilers at the front head above the top row of tubes, as at *A* in the figure, then went back about three-quarters the boiler length to *B*, then turned at right angles to the center of the boiler and terminated in an elbow and a short length of pipe. This last piece of pipe turned up, as shown at *C*, so that when the water discharged it hit the top of the shell, where it broke up in a finely divided spray.

I arranged the pipes as shown at *D* and *E* and which I have since found was the way the boilers were piped when installed. I put a tee in place of the last elbow and extended two lengths of pipe, terminating them with forty-fives. The feed water now discharges into the boiler water, and the excessive drop has been eliminated.

What could have been the engineer's reason for altering the arrangement? FREDERICK PAKES.

Stanton, Mich.

Comments from Readers

Checking Three-Phase Wattmeter Connections

The account of troubles in connecting up three-phase wattmeters in *Power* for June 17 is interesting, but a little misleading as the diagram does not show the polarity markings of the transformers and gives the impression that the correct connections are altogether a matter of cut and try and finally hitting the lucky combination. Electrical science has progressed considerably beyond this point, and all sorts of meters can be connected up with the assurance that they will read correctly if instrument and transformers are not damaged and, conversely, the correctness of meter readings checked by checking up the connections.

Since, frequently, a diagram is unavailable when needed most, the following explanation of how to make

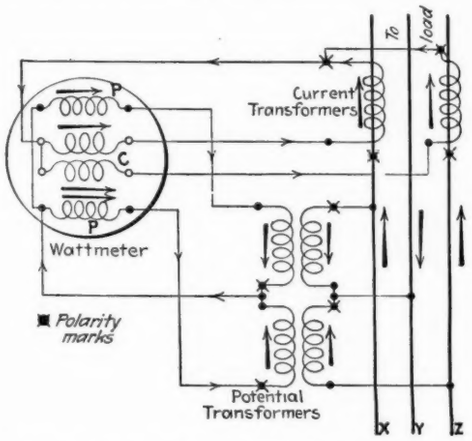


Diagram of polyphase wattmeter connections

one may clear up some puzzles for those who have been connecting them as a matter of routine and enable them to pass on a set of connections with certainty.

Instrument transformers have one connection of each winding marked with white, these being shown so that with direction of current going in at the white pole of the primary the direction will be out at the white pole of the secondary, these directions as well as those in the following description referring to instantaneous direction of current at any instant.

The two-element wattmeter should be connected so that the current flows the same way in both current coils *C* and potential coil *P* of both elements. The current and potential coils of each element must also be connected on the same phase. Assume a direction of current in the three conductors *X*, *Y* and *Z* up in *X* and *Z*, and down in the center wire *Y*, then by sketching in the most convenient location of primary connections, the direction of flow in the secondary will necessarily follow and connections must be made to potential and current studs of the meter to secure the desired direction of flow through the instrument.

I have found that this method of reducing the job to its elements simplifies connecting up a wattmeter so that the average engineer may undertake it with assurance of accurate results. H. D. FISHER.

New Haven, Conn.

Burning Coke Breeze

The report of the experiment of burning coke breeze as made by C. C. Herman, in the June 24 issue is interesting, but the results obtained are quite different from those secured in my plant. The material that he burned was evidently inferior to mine, but both are worthy of consideration. The breeze that I used was screened out of coke made in the local gas works, and is usually not considered first-class fuel. Much of it was as fine as anthracite dust, but some of it was as large as nut coal.

The boiler under which this test was made, is of the horizontal, return-tubular type, and of the following general dimensions:

Area of heating surface, sq.ft	1,254
Length of grate, in.	66
Width of grate, in.	66
Grate area, sq.ft.	30.25
Ratio of heating surface to grate area	41.4
Distance from grate to boiler, in.	30
Distance between bridge wall and boiler shell, in	12

The breeze was burned on a dumping grate in sections 6 in. wide, having $\frac{1}{2}$-in. bars and $\frac{3}{8}$-in. air spaces. The regular fireman was employed without special instructions.

As I was not familiar with this fuel at that time, I avoided trouble by experimenting independently, as follows: Having a good coal fire, I spread breeze over it evenly and watched the results. As it continued to make plenty of steam through the day, I felt safe enough at night and let the fire go out. The next day I used enough wood to kindle a fire and used nothing else but breeze for a run of 10 hours. My only object that day was to find out if the breeze would make steam enough to keep the boiler on the line, and we had steam enough all day. I then proceeded to make a regular boiler test that would be valuable.

The steam generated was tested on a calorimeter and found to be dry. The feed water passed through a calibrated meter, and the readings were corrected. As the temperature of the water was 200 deg.. the weight was taken at 60 lb. per cu.ft. A sample of the breeze was dried and found to contain 0.056 per cent of moisture, so the weight of the fuel was corrected on this basis. The following items were secured:

Duration of test, hours	10
Average steam pressure, lb.	75
Dry breeze burned, lb.	4,952
Water evaporated, actual conditions, cu.ft.	677.7
Weight at 60 pounds per cu.ft.	40,662
Water evaporated per pound of breeze, lb.	8.21
Per cent of boiler rating developed	101.6

It will be noticed that the rate of evaporation is practically as high as when burning soft coal. Forced draft is used, but this term should be qualified for this

plant. A steam blower creates the draft, but inasmuch as it varies from 0.4 to 0.7 of an inch of water, it cannot be called excessive. Steam is delivered to the blower through a ¾-in. pipe. No account is made of the ashes, as the only points worthy of consideration here are the weight of water evaporated per pound of fuel burned and the boiler rating developed.

New Haven, Conn. W. H. WAKEMAN.

Speed Regulation of Underfeed Stokers

In reply to J. E. Richardson's contribution, "Speed Regulation of Underfeed Stokers," in the July 1 issue, I wish to state:

Mr. Richardson's tests, made on a large underfeed stoker, are interesting, but fail to prove that stoker-speed regulation is a fad, imaginary in value, or questionable in practical application.

The tests are of too short duration to be conclusive, for the following two reasons: (a) The flywheel effect of the large fuel bed blurs the results. (b) The initial conditions of the fires are the determining factors in short tests.

Starting with the fire in good, poor or average condition, it is possible at will to duplicate or reverse the results Mr. Richardson obtained. Coal feed regulation of stokers has to be judged over longer periods—days, preferably weeks—to show real results that create dollar savings.

This regulation can be done manually as in 75 per cent of the plants in an erratic intermittent way, by observing the fires every 15 to 20 min., according to Mr. Richardson (preferably with a blue glass because you can see more!).

This regulation can also be done by machines called regulators, without any human interference, as I described in my contribution, page 676, April 29 issue.

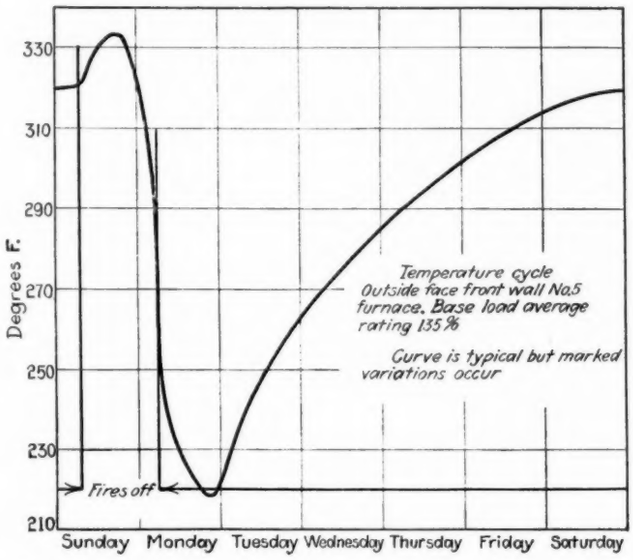
The regulation in the Lowellville station produces over a month's operation, remarkable results, that are directly in contradiction with the conclusion Mr. Richardson tries to draw from short tests, only because it is a scientific stoker speed control synchronized at all times with the air supply.

J. F. SHADGEN, Combustion Engineer,
New York City. Stevens & Wood, Inc.

Why Does the Temperature of the Furnace Walls Increase After Fires Are Extinguished?

Referring to my inquiry, "Why Does the Temperature of the Furnace Walls Increase After Fires Are Extinguished?" which appeared in the June 17 issue, a further study of the temperature readings has been made and a temperature curve for a typical week is submitted herewith. Note that the maxima and minima shown on the curve are less than average and that the extreme variations are usually more marked.

It seems that an appreciable flow of air takes place through the wall even though it is 22 in. thick, new and in good condition. With 0.35 in. draft or negative pressure in the furnace causing this flow of air, the result is a steeper temperature gradient and lower average temperatures. When the fires are extinguished and the dampers closed, this flow of air ceases. The temperature of the furnace side of the wall decreases rapidly, but there is sufficient thermal storage in the wall to raise the temperature of the outside face. After this thermal storage is exhausted, the outside face temperature will begin to drop. When the furnace is once more put into operation, the cooling flow of air is started, causing a still greater temperature decrease until such a time as the heat transfer outward will



Curve shows temperature of outside face of front wall for seven-day period

have overcome the cooling action. A gradual rise will then result until after about 100 hours, when the terminal temperature will have been reached.

Powell River, B. C., Canada. M. S. GEREND.

Heat Transfer with Superheated Steam

In the June 3 issue C. E. Colborn, answering my comments on heat transfer with superheated steam (March 25), challenges any one to show tests that will prove that his conclusions are wrong. I am sorry that actually we Germans are in such a poor financial situation that I cannot offer to do so, especially as the theory is absolutely against Mr. Colborn. Mr. Sprague gives in his paper the conclusion of numerous tests, but none of these tests themselves. Therefore I beg to answer Mr. Colborn in the same way and discuss his theory.

Mr. Colborn says that with equivalent conditions the resistance to heat transfer from the cooling water to the steam-side surface is not affected by the substitution of superheated for saturated steam. Suppose he understands the coefficient α_w (B.t.u. transferred per square foot per hour, per degree F. temperature difference between the water-side tube surface and the water) as resistance to heat transfer, I agree with him. Of course it follows then that the tube surface on the water side must have a lower temperature by substituting superheated for saturated steam, unless the rate of heat flow is as great with superheated as with saturated steam.

As the quality of the heating surface does not change, the same difference of surface temperature on both sides corresponds to the same rate of heat flow; the tube surface on the steam side will therefore also have a lower temperature by substituting superheated for saturated steam, unless the rate of heat flow is as great with superheated as with saturated steam.

This is, in other words, what Mr. Colborn writes, but he forgets to give the final conclusion, namely that the coefficient a_s (B.t.u. transferred per square foot per hour per degree F. temperature difference between the steam and the steam side of the tube) is some hundred times lower with superheated than with saturated steam and that, therefore, the higher difference of temperature between steam and steam-side tube surface is more than counterbalanced by the poor value of a_s on the superheated steam side. It may ,therefore be allowable to challenge Mr. Colborn to show his tests proving that the tube temperature rises or remains the same by the substitution of superheated for saturated steam, which would prove that the rate of heat flow is greater or as great with superheated as with saturated steam. Of course the coefficient of heat transfer, as mentioned by Mr. Colborn (the difference being calculated between the initial steam temperature and the mean water temperature), has no relation to the actual amount of heat transfer. The coefficient of heat transfer must be calculated separately for the three zones (superheated steam, saturated steam, condensed water) and the mean temperature difference between steam and water must be considered for each of them.

M. HIRSCH,
Frankfort, Germany. Consulting Engineer.

European Turbine Efficiencies

I was much interested by the editorial in *Power*, May 6, on the subject of "Re-Invention." This is a particularly appropriate time for this editorial, as I believe many people are under the impression that the various schemes you mention are new inventions. As a matter of fact, several years ago *Power* published abstracts from a notebook of James Watt in which many of these things were suggested, although in Watt's day the mechanical arts as well as the costs of labor and fuel, were such as to make them both impractical and uneconomical.

I think your statement, "Thermal efficiency must always step aside in favor of commercial efficiency, and as long as coal was cheap there was no incentive to make use of systems demanding high initial cost for the machinery," is a timely comment in view of the present developments in Europe. A particular case that has recently come to my attention is the trend of European turbine design, which has advanced in the direction of high efficiency, due to the present economic conditions in Europe. The high cost of coal and labor apparently justifies the investment of much larger sums for turbines having a slight improvement in efficiency over turbines of a few years ago, the gain in efficiency having been effected by the use of principles long known but hitherto not commercially practicable. One manufacturer has secured a patent on a turbine having a relative steam velocity of 330 to 460 ft. per sec., claiming the high efficiency obtained at these low velocities as a discovery of great value and for this reason patentable.

This contention, at first blush, seems to be sustained by the tests conducted during the last two years by the British Electrical & Allied Manufacturers' Association. These tests, which refer to converging nozzles of various forms, show a high efficiency peak around 330 to 460 ft. per sec. and another one at about 1,300 or 1,480 ft., the latter being the field covered by the U. S. Patent No. 1,062,471, of Josse & Christlein. The discrepancies, however, between the claims and these tests are obvious, since the nozzle tests indicate a difference of efficiency of only about 3 per cent between the low-velocity peak and the high-velocity peak, whereas improvements in efficiencies amounting to as much as 10 per cent and over are claimed for the low relative velocity range between 330 and 460 ft. It has been common knowledge among turbine manufacturers for many years that this friction varies approximately as the square of the disk diameter and the cube of the blade speed, and is directly proportional to the density of the steam in which the disk revolves. In other words, the revolutions remaining constant, the disk friction is proportional to the fifth power of the diameter and directly proportional to the density. It is obvious that a reduction in blade speed at constant revolutions enormously reduced the wheel friction.

The improvement in efficiency by reducing the wheel diameter and blade speed is also in part due to the fact that European designers use wheel-friction constants based on experiments made by spinning wheels in dead steam, which gives calculated values that are too low, and consequently, reducing the wheel diameter and blade speed eliminates most of the error resulting from underestimating this loss, and a gain in efficiency is observed which is incorrectly wholly attributed to reduction of blade losses and improvement in nozzle efficiency.

Furthermore, it has been known that increasing the number of stages in a turbine reduces the loss by leakage through the inner stage packing, since the pressure drop per stage is reduced and the benefit of reheat and reduction of leakage from stage to stage is gained in the lower stages. It has been known for many years that the blade losses in a turbine diminish rapidly with reduction in relative velocities, and it was known that the nozzle efficiency improved as lower velocities were used. This is shown by curves for blade losses shown in "Moyer's Steam Turbine," Fourth Edition, in which a curve for blade losses is shown on page 101, and a curve for nozzle efficiency published in the Journal of the American Society of Naval Engineers, May, 1911.

With such common knowledge regarding the reduction of all losses with decreasing relative velocity, it was obvious to all turbine engineers that were the price of coal sufficiently high to justify the initial additional investment, the correct way to design a turbine would be with many stages, using very low relative velocities, the data indicating that efficiencies would increase down to the lowest that commercial conditions will ever justify.

In view of the turbine art, as briefly outlined in the preceding paragraphs, it seems apparent to me that certain European manufacturers are trying to gain a monopoly of the turbine business by patenting long-known facts which have not previously been put into practice solely because the economic conditions in the past would not justify their adoption, although their thermal advantages were recognized.

The turbine situation in this country is unchanged by these new developments. As soon as the economic conditions warrant the adoption of turbines of lower blade speed, and consequently, increased number of cylinders, but of higher efficiency, the manufacturers in this country will no doubt bring forward designs to meet the new conditions.

H. F. SCHMIDT, Consulting Engineer,
Philadelphia, Pa. Westinghouse E. & M Co.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Use of Superheated Steam for Reciprocating Engines

How is an advantage obtained from supplying superheated steam to a reciprocating engine? *C. M.*

The principal benefit is derived from counteracting cylinder condensation, especially to obtain the presence of dry steam at the time of cutting-off; and additional advantage is gained from having the initial steam so highly superheated that it will be dry throughout expansion.

Relative Length of the Water and Steam Cylinders of Direct Acting Steam Pumps

Why are the water cylinders of direct-acting steam pumps made so much longer than the steam cylinders? *R. S. L.*

Greater clearance spaces in the ends of the water cylinders are advantageous rather than objectionable, as in steam cylinders, since they afford easy passages for the water into and out of the cylinder, and in addition, the greater length provides latitude for adapting the length of stroke to the steam cylinder without serious reduction of the clearance that is desirable for the ends of the water cylinders.

Rumbling Safety Valve

What would cause a spring-loaded safety valve to rumble on its seat, and how can this be remedied? H. A.

A spring-loaded safety valve may rumble on its seat when the valve leaks and needs reseating or when the boiler pressure is maintained at or a little above the pop pressure and there is not sufficient assistance of the escaping steam for the valve to be held clear of its seat until the boiler pressure has become reduced below the pressure at which the valve is set to pop. This reduction of pressure is called the blow-down, and most modern spring-loaded safety valves are provided with means for varying the amount of blow-down and incidentally for causing the valve to be held clear of its seat for a considerable period after the valve has popped.

Protection of Blowoff Pipe

How can the blowoff pipe of a return-tubular boiler be prevented from burning out without too much obstruction of the combustion chamber? *J. M. C.*

Blowoff pipes of return-tubular boilers sometimes become burned when protected by a shield or baffle of firebrick or heavy cast iron, owing to the intense heat of the combustion chamber, and the trouble from burning is more likely when the pipe is not kept clear of scale. The best results are obtained when the pipe is covered for its full length within the boiler setting with a non-conducting material, or even cast iron, leaving an air space of several inches between the blowoff pipe and the covering, carried to the outside of the setting for circulation of cool air. Better circulation of the cooling air would be obtained by having a separate vent to connect the highest part of the air space with the open air as well as the place where the blowoff pipe extends through the setting. A good ventilated covering will not only keep the pipe cooler than baffles, but also cause less obstruction of the combustion chamber of the boiler setting.

Effect of Throttling or Wiredrawing

What effect has throttling or wiredrawing on the power and economy of an engine? *W. B. J.*

Throttling and wiredrawing or drop in pressure due to the resistance of ports and passages, has the effect of reducing the power output and to some extent reduces the economy of an engine. During admission of steam the pressure within the engine is less than the pressure of steam presented to the throttle, and there is relatively higher terminal pressure. Some operating advantage is obtained from the quality of the steam being dryer at the reduced pressure, but the heat available is reduced by the lowering of the pressure. The amount of loss from throttling or wiredrawing in a given engine depends on the pressure and dryness of the initial steam and the amount of reduction of the pressure.

Speed of Synchronous Motor Driven Clock on Curve Drawing Meter

The company I am with has installed some curve-drawing wattmeters, the ribbon feed of which is driven by a Warren self-starting synchronous motor, the speed of which is 1 r.p.m. Obviously, this motor is not of the usual type, as it would require 7,200 poles on 60-cycle current to give a speed of 1 r.p.m. I would be pleased if you will explain the feature of this motor. *E. C. M.*

The speed of this motor is 3,600 revolutions per minute on a 60-cycle circuit, consequently the motor has two poles. The motor speed is geared down to one revolution per minute within the clock. The motor and gearing are combined in the housing through which the drive shaft extends. Therefore, the shaft that you refer to as revolving one revolution per minute is not that of the motor, but of the low-speed gear. These synchronous-motor driven clocks are geared for one revolution per minute, and then suitable gearing used from this speed to meet the conditions of whatever is to be driven from the clock's shaft.

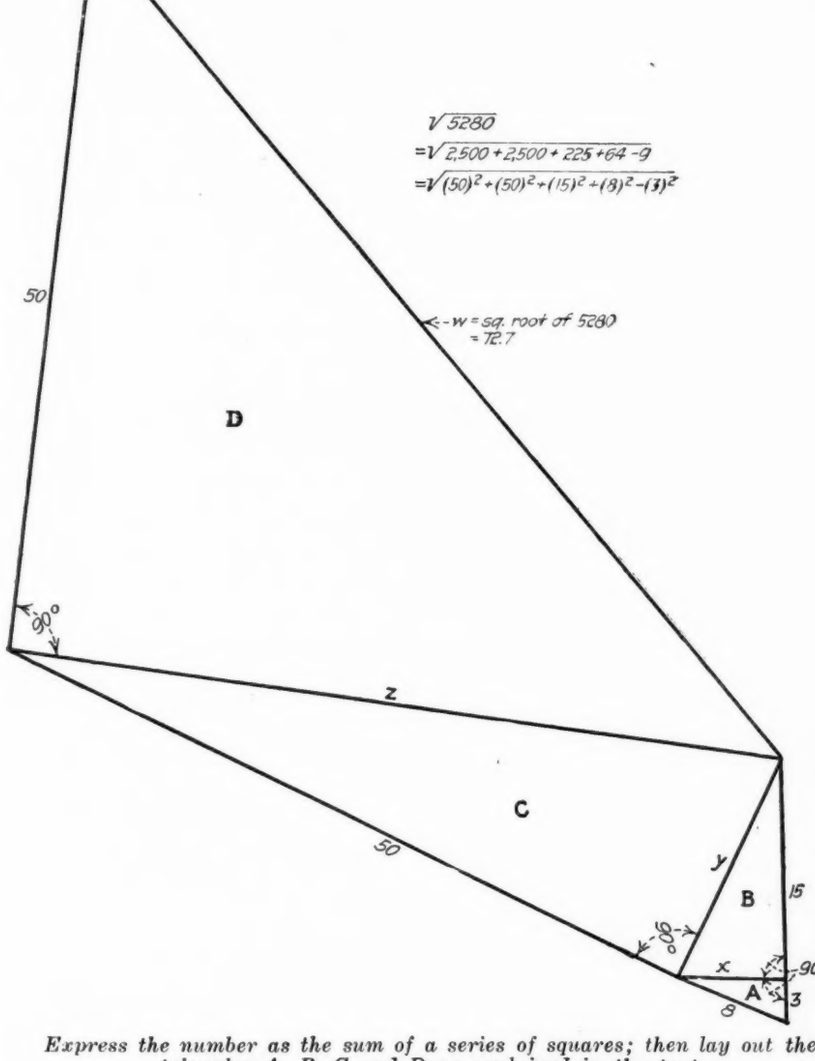
Here and There in the Power Plant

Sidelights on things generally used but less generally understood

Mechanical Determination of Square Roots

By Charles A. Pease

THE method to be shown for extracting square roots requires a celluloid triangle and a scale. The accuracy is limited only by the scale used.



Express the number as the sum of a series of squares; then lay out the triangles A, B, C and D as explained in the text

It is especially useful in drafting for laying out squares of a given area.

This process is based on the fact that in any right-angled triangle the hypothenuse represents the square root of the sum of the squares of the two legs; and that, inversely, either of the two legs represents the square root of the difference between the square of the hypothenuse and the square of the remaining leg.

The first step is to divide the given number into two or more known squares. The squares of the numbers 1 to 10 are easily remembered (1, 4, 9, 16, 25, 36, 49, 64, 81 and 100), while the squares of a few higher numbers, if not remembered, are easily obtained, as $(15)^2 = 225$, $(20)^2 = 400$, $(25)^2 = 625$, $(30)^2 = 900$, $(40)^2 = 1{,}600$ etc.

Suppose we wish to obtain the square root of 13. Now 13 = 9 plus 4; hence $\sqrt{13} = \sqrt{9+4} = \sqrt{(3)^2 + (2)^2}$. Construct a right-angled triangle one leg of which is 3 parts and the other 2, using any convenient scale. On the same scale the hypothenuse represents the square root of $(9 + 4) = \sqrt{13}$.

But suppose we want the square root of 35. Our nearest perfect squares will be as follows: $35 = 25 + 9 + 1$; hence $\sqrt{35} = \sqrt{25 + 9 + 1}$. Using 1 and 3 respectively for the two legs, the hypothenuse will then equal the square root of $(9 + 1) = \sqrt{10}$. Using this hypothenuse as one leg of a new triangle, we erect a perpendicular of 5. The hypothenuse of this new triangle will represent the square root of $(10 + 25) = \sqrt{35}$.

Sometimes it is of advantage to reverse the process, using minus quantities. In the last case, for example, 35 might have been resolved as follows:

$35 = 36 - 1$ = difference of squares of 6 and 1. In this case we make a base of indefinite length, erect a perpendicular of 1, and produce a hypothenuse of length 6. The length of base thus obtained represents the square root of $(36 - 1) = \sqrt{35}$.

Negative quantities, if any, should always be determined and used first. Also, the smaller positive qualities should be used before the larger, to keep well-proportioned triangles, which allow greater accuracy than very thin ones.

An example and diagram for a fairly large number, requiring several operations, will make everything clear.

Required: the square root of 5,280.

$5{,}280 = 2{,}500 + 2{,}500 + 225 + 64 - 9 = (50)^2 + (50)^2 + (15)^2 + (8)^2 - (3)^2$

Turning to the diagram, the first step is to construct triangle A with leg 3 and hypothenuse 8. Then $X = \sqrt{(8)^2 - (3)^2}$.

Use X as one leg of the unit triangle B and 15 for the other. Then the hypothenuse $Y = \sqrt{(15)^2 + (8)^2 - (3)^2}$.

In the same way the triangle C, having Y for one leg and 50 for the other, has a hypothenuse Z equal to $\sqrt{(50)^2 + (15)^2 + (8)^2 - (3)^2}$. Using this for one leg of the triangle D and 50 for the other, the final hypothenuse W is equal to

$$\sqrt{(50)^2+(50)^2+(15)^2+(8)^2-(3)^2} = \sqrt{2{,}500+2{,}500+225+64-9} = 5{,}280.$$

Scaling W gives the answer, 72.7.

It is entirely unnecessary to measure any of the unknown quantities, X, Y, Z, etc., until the last and desired value is obtained.

In the example and diagram given, if the work has been carefully done, the final line W will be found to measure about 72⅝ units, or 72.7, while the result by the direct mathematical extraction of the root gives 72.663+, a result close enough for most purposes.

Fall in Pressure in Hydraulic Turbine Penstocks Due to Acceleration of Flow*

By S. LOGAN KERR
Assistant Hydraulic Engineer, I. P. Morris Department, The William Cramp & Sons Ship & Engine Building Co.

THE subject of water hammer as manifested by the rise in pressure due to the retardation or complete stoppage of flow in pipe lines and hydraulic turbine penstocks, has been dealt with at length by a number of prominent engineers, including Joukovsky, R. D. Johnson, Allievi and N. R. Gibson. Several important theories have been developed whereby this rise in pressure can be calculated accurately. On the other hand the fall and rise in pressure resulting from the acceleration of flow has not received the same attention.

When the flow in the closed conduit is retarded or stopped completely, the kinetic energy of the water, following the law of the conservation of energy, is converted into other forms which manifest themselves as increased pressure or internal friction. Conversely, when a fluid is at rest in a closed conduit, energy of some form must be supplied to set it in motion, and this is accomplished at the expense of the hydrostatic pressure.

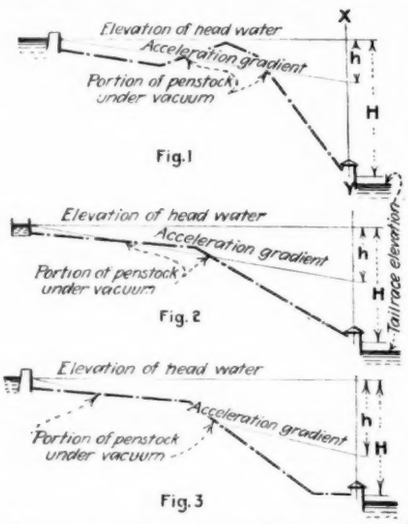
Providing for Pressure Changes in Penstocks

The rise in pressure in the penstock may be provided for by increasing the strength of the pipe, by using relief valves, or by causing the retardation of flow to take place at such a slow rate that the increase in pressure is kept within safe limits. Excessive reduction in pressure, however, can be avoided only by having the opening of the valve or turbine gates at the lower end of the penstock proceed at a rate sufficiently slow that the safe limit is not exceeded. If the penstock profile is such that for a rapid acceleration of flow there are portions where the pressure would fall below atmospheric, a vacuum would be formed which may cause the pipe to collapse. This condition has frequently been met with in practice, and several examples of actual penstock profiles are shown in Figs. 1, 2 and 3, together with the so-called "acceleration gradient" caused by a rapid opening of the turbine gates.

Since the variation in pressure is very nearly a direct function of the length for uniform gate movement with respect to time, if the maximum fall in pressure at the turbine is known, a line called the "acceleration gradient" can be drawn, giving the fall in pressure at intermediate points; that is, at a point halfway between the penstock intake and the turbine, the decrease is about one-half that occurring at the turbine, and for one-quarter length about one-fourth of the maximum.

Referring to Fig. 1, the static pressure H is shown as the distance between the penstock center line and the headwater elevation, but when the turbine gates are opened rapidly, the pressure is measured instantaneously as the difference between the penstock center line and the acceleration gradient line.

Whenever the acceleration gradient falls below the profile of the penstock, this particular section will be under a partial vacuum, thus causing a dangerous condition, which can be corrected only by slowing up the rate of gate movement or else altering the profile to maintain a positive pressure under all conditions.



Figs. 1 to 3—Profile of penstock showing fall in pressure due to opening of turbine gates

In some cases the conditions are so extreme that a surge tank must be supplied in order to secure proper regulation of the water wheels, and also to correct dangerous conditions resulting from excessive rise or fall in pressure. However, as far as the treatment of the fall in pressure is concerned, it will be assumed that the surge tank has the effect of reducing the length of the penstock by bringing the point of relief nearer to the turbine.

The two examples, Figs. 2 and 3, illustrate less severe conditions than that shown in Fig. 1, but draw attention to the need for an accurate predetermination of the maximum fall in pressure due to the opening of the turbine gates, as a means of insuring the safety of the plant and avoiding the collapse of the pipe line.

General Theory

It is now generally accepted that the phenomenon of water hammer consists of successive pressure waves surging up and down the penstock, caused by changes in velocity and governed by definite laws. The waves in the case of a rise in pressure are initially supernormal, but upon traveling up the penstock to the intake or point of relief, they are reflected and return to the origin, where they are again reflected but this time as waves of subnormal pressure. These subnormal waves go through the same cycle and, upon reaching the origin the second time, are reflected as the original supernormal waves. The summation of these waves of alternating magnitude at any particular instant will give the rise or fall in pressure due to the change in velocity which has occurred.

The essential difference between the rise and fall in pressure is that in the case of the rise in pressure the initial waves are supernormal, whereas in the case of the fall in pressure the waves are subnormal initially. Thus the waves for the acceleration of flow correspond with the reflected subnormal waves in deceleration occurring after the first supernormal waves have traveled up to the point of relief and returned to the origin; that is, we would consider the cycle of waves resulting from the opening of the penstock valves as being $\frac{2L}{a}$ seconds out of phase with the cycle for closure, where L is the length of penstock in feet and a the velocity of the pressure wave in feet per second. The value of a depends upon the compressibility of water and the material, the thickness, and the diameter of the pipe line, and is independent of the velocity of flow in the pipe line, the change in pressure or the initial pressure. The speed of propagation of the pressure waves may be developed analytically, as is done by Allievi in his book on water hammer, but the final formula only is given here.

$$a = \frac{12}{\sqrt{\frac{W}{g}\left(\frac{I}{k} + \frac{D}{Ee}\right)}} \qquad (1)$$

where

a = Velocity of the pressure wave in feet per second.
g = Gravitational unit.
k = Voluminal modulus of elasticity of water in pounds per square inch.
D = Diameter of pipe in inches.
e = Thickness of the walls of pipe in inches.
E = Modulus of elasticity of the material of the pipe walls.
W = Weight of one cubic foot of water.

The application of the theory on which the variation in pressure at any time during or after the opening of the turbine gate may readily be calculated, involves considerable complication and will not be given here. From careful study of a number of actual calculations and also from research, it

*Abstract from a paper that formed part of the 1924 National Electric Light Association's Hydraulic Power Committee's Report. In the original paper the author gives an extensive mathematical analysis of the problems involved in the fall of pressure in penstocks when the turbine gates are opened.

has been found if the movement of the turbine gates or the opening of the penstock valves is uniform with respect to time, the maximum fall in pressure occurs exactly $\frac{2L}{a}$ seconds after the movement has started. From the series of equations derived from the original formulas, the expression for the fall in pressure at the end of the first interval of time may be developed, and the following results:

$$h = \tfrac{1}{2}\left[-K + \sqrt{K^2 + 4KH}\right] \quad (2)$$

where

$$K = \left(\frac{2LV}{gT\sqrt{H}}\right)^2 \quad (3)$$

h = Maximum fall in pressure below normal in feet due to an increase from zero of

V = velocity in feet per second in the penstock when the gates are open to the desired value;

L = Length of penstock in feet;

H = Effective head on the turbine in feet.

T = Time in seconds required for the opening of the turbine gates (must be greater than or equal to period of penstock $\frac{2L}{a}$). The actual values of a are not required in calculations except where very short governor times are used and for penstocks of exceptional length where the period of the penstock reaches values greater than one second. Where the value of a is required it can be determined from formula (1).

It will be noticed from the foregoing that the maximum fall in pressure under these conditions is independent of the velocity of the pressure wave and hence of the materials of the pipe construction, its diameter or thickness. The value of the velocity of the pressure wave, however, enters into the formula since it limits the value of T, the total time of movement.

In order to simplify the solution of the various problems involving the fall in pressure due to the acceleration of flow, the chart shown in Fig. 4 was prepared. This chart is based on equation (2), which gives the maximum fall in pressure for the movement of the turbine gates with respect to time.

Referring to Fig. 4, by calculating the value of K and knowing the normal head, the maximum fall in pressure may be read directly from the chart. The following numerical example serves to illustrate the use of this chart.

Assume a plant with an effective head of 300 ft., a penstock 500 ft. long, with an average velocity under full load of 7 ft. per sec. Assuming that the turbine gates open in 1.75 sec., by calculating K from the foregoing data, using formula (3) there is obtained,

$$K = \left(\frac{2 \times 500 \times 7}{32.16 \times 1.75 \times \sqrt{300}}\right)^2 = 51.6$$

Referring to the chart, by following the co-ordinate lines corresponding to 300 ft. head to a point where it intersects the curve for K equal to 51.6 ft. it will be found that the fall in pressure corresponding to this point is equal to about 102 ft., as indicated by the dotted lines.

Use of Chart Makes Calculation Simple

It will be seen from the foregoing that the calculation is made a relatively simple matter by the use of the chart, involving only the determination of the value of K from the physical constants obtaining with any given case.

It is frequently desirable to determine the minimum time that may be allowed for a complete stroke of the turbine gates from closed to open in order not to exceed the maximum allowable fall in pressure fixed as a range of safe operation for a given plant. Referring to Fig. 3, the profile of the penstock has been plotted against the true length of the penstock and not against a horizontal projection. As was previously noted, the variation of pressure is a direct function of the penstock length for uniform gate motion. If, at the critical point marked "Portion of penstock under vacuum," an allowance was made so that the acceleration gradient would not fall below the profile but maintain the desired margin above it, this might properly be called the maximum allowable acceleration gradient. This margin may be as low as two or three feet in the case of a low-head plant, and be as great as fifty or more feet in the case of plants that are under very high heads.

Where this gradient intersects the vertical line drawn through the power house as shown, a new value of h is obtained which represents the maximum allowable fall in pressure for

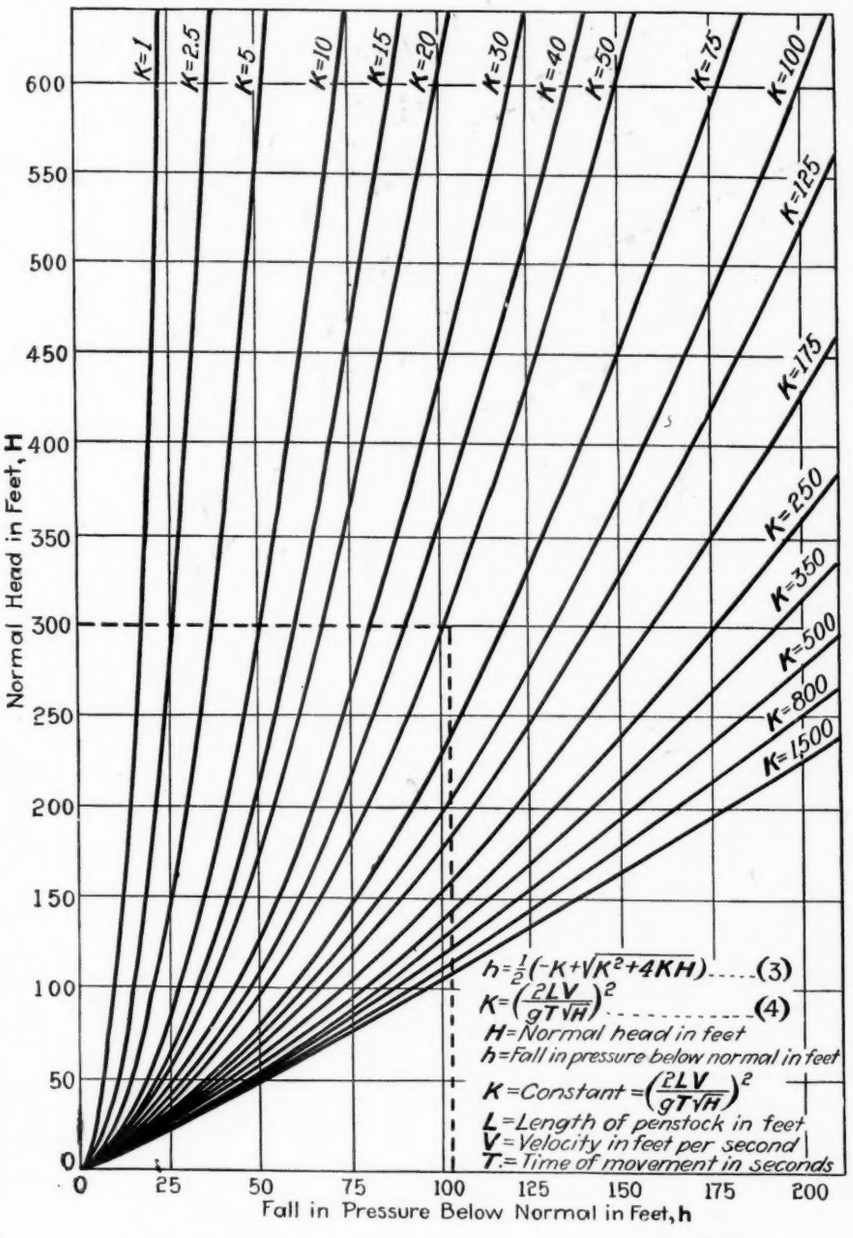


Fig. 4—Chart for calculating fall in pressure in penstocks

safe operation to avoid collapse of the pipe line. Having therefore determined this value h, the value of K and hence T may be determined from equation (3). However, it is simpler to change this equation to:

$$T = \frac{2\,LV}{g\,H}\,\beta_x \qquad (4)$$

where

$$\beta_x = \left(\frac{1 - x}{x^2}\right)^{\frac{1}{2}} \qquad (5)$$

and all other symbols are the same as defined under equation (2) except that x is equal to the ratio of the fall in pressure to the total head; that is

$$x = \frac{h}{H}.$$

In order to simplify calculations, a curve, Fig. 5, has been prepared giving

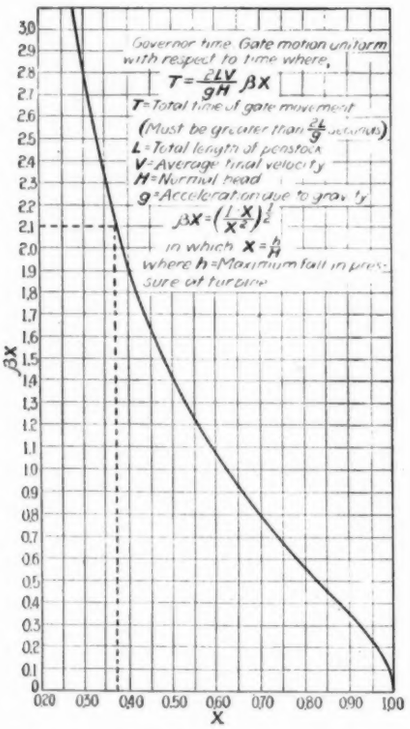

Governor time. Gate motion uniform with respect to time where,
$T = \frac{2LV}{gH}\beta X$
T=Total time of gate movement
(Must be greater than $\frac{2L}{g}$ seconds)
L=Total length of penstock
V=Average final velocity
H=Normal head
g=Acceleration due to gravity
$\beta X = \left(\frac{1-X}{X^2}\right)^{\frac{1}{2}}$
in which $X = \frac{h}{H}$
where h=Maximum fall in pressure at turbine
βX
X

Fig. 5—Chart for use in determining time of turbine-gate opening

the values of βx for various values of x. In this manner the minimum allowable time can be readily calculated. There is only one restriction; the time T can never be less than $\frac{2L}{a}$ seconds. A numerical example illustrating this is given here:

In a given plant where the normal head of 400 ft., the length of the pipe line 1,500 ft., average velocity of the water in the penstock of 10.15 per sec., the allowable fall in pressure is 150 ft. below normal.

In this problem

$x = \frac{150}{400} = 0.375$ and from Fig. 5,

$\beta x = 2.1$,

Then $T = \frac{2 \times 1{,}500 \times 10.15}{32.16 \times 400} \times 2.1 = 5.0$ seconds

The Internal-Combustion Engine*

By Charles Edward Lucke†

STATIONARY applications of the internal-combustion engine have brought self-contained generation of power direct to the point of use, and this has had revolutionary effects on the living conditions and labor operations that must be conducted in isolated places, such as the farm, the mine and the forest. It has also contributed materially to the progress of more settled communities by making power available to consumers at power costs lower than are possible by local generation in small steam plants. In addition, it now supplements and effectively co-operates with electric systems distributing to distant small consumers. With only partial statistical returns, the figures available account for a total of 284,000,000 hp. in internal-combustion engines in use in the United States, of which about 240,000,000 hp. are represented by automobiles and trucks.

Superiority of Internal Combustion Engines

The internal-combustion engine has reached its present stable status as a result of certain inherent characteristics that have contributed to its adoption on two wholly different bases. These are: First, suitability for a given purpose to a degree superior to any other alternative; and second, economy in operation superior to alternate or competitive power sources, when both are equally suitable.

Superior suitability is primarily responsible for the controlling position of the internal-combustion engine in all transportation applications and in small-power stationary applications. For large marine and stationary installations operating economy plays a proportionately larger part in the resulting adoption against competitive steam or transmitted electric power. In the very large capacities, typical of big central stations, the internal-combustion engine yields to steam or hydraulic turbines because very large internal-combustion engines cannot be built.

Local Conditions Influence Choice

It appears, therefore, that the internal-combustion engine as a prime mover is today supreme in units of small horsepower for all purposes, stationary and transportation, because of superior suitability, and in medium-size units because of lower power costs. At just what size its supremacy is successfully challenged by steam depends on local economic conditions, especially fuel prices, and fuel prices judged with reference to labor wage rates, but the trend of competitive size is upward.

To aid and guide this further development, there is now available a body of scientific data, supported by a mass of experience and facts, in the hands of a growing class of specialist engineers, skilled in design and in analysis of the economics of use, such as never existed before. It, therefore, must be concluded that for the internal-combustion engine the future is bright, because the foundations have been well laid on a substructure of sound principles.

The Engine for Small Plants

For stationary power generation cost of the power controls the selection between two or more alternatives equally suitable, and this is the situation in large units, especially in settled districts. On the other hand, very small units obtainable as internal-combustion engines have no alternatives, especially in country districts, so they have been adopted in greater numbers; even near electric transmission lines they do not seem to feel the competition of the electric motor.

In intermediate sizes the situation is more irregular and selection is controlled partly by local favoring conditions and partly by costs. Examples of this are found in the oil engine replacing the steam pumping stations on the thousands of miles of oil pipe lines, and gas-engine driven compressors, used in large numbers without competition on natural-gas pipe lines, both small-sized gathering compressors, and large ones of 1,000 hp., and more on main lines. Somewhat similar is the situation typical of the small town in sections of the country that are thinly settled, where oil-engine-driven pumps and electric generators supply the town with water and electric service. There is a large number of these and they are increasing in popularity, especially in districts where water is poor, fuel oil better or more available than coal, and the size moderate; in fact, over one-half of all the central stations are equipped with oil engines.

With the exception of the small general-purpose farm type of engine and the semi-automatic electric generating lighting plant, which are stronger, the stationary gasoline engine has largely disappeared, being replaced by oil engines burning cheaper fuel oil.

Gas Engines Are Disappearing

The small gas engine, once so largely used on both natural gas, and, in cities, on manufactured illuminating gas, has suffered a decline, due mainly to the growth of electric distribution and electric-motor competition. There are, however, some still in use where conditions are favorable, and one typical example of this is found in their adoption by telephone companies which require their electric supplies to be absolutely independent of the hazards of electric line wires, especially in the country.

The large gas engine of several thousand horsepower per unit, developed to a high state of mechanical perfection in the double-acting tandem style, has not grown as was once expected. In large capacities the steam and hydro-electric systems have been able to show better power costs with

*Extract of paper read at the First World's Power Conference, London, June 30, 1924.

†Professor of Mechanical Engineering, Columbia University, New York.

prevailing low fuel prices. This result is due to a difference in fixed charges greater than the difference in fuel and other operating disbursements. There has been a corresponding decline in the gas-producer-gas-engine power plant, but in this case the rise of the oil engine is the main cause, as the producer-gas engine cannot compete with oil engines at prevailing fuel, oil and coal prices.

Advent of the Oil Engine

In the stationary-engine field the outstanding feature is the rapid development of the injection oil engine. This is due partly to the demand for gasoline which made available great quantities of fuel oil, but it is also due to a steady progressive improvement of oil engines themselves in styles and sizes suited to the service and to the type of operators available.

There is a growing recognition of the value of the oil engine by central station and utility interests as co-operative agencies working in connection with their steam and hydro systems. This takes several different forms: (a) Isolated beyond the power lines to serve a light-load district until line extension is later justified; (b) on the line at outlying substation points, replacing or supplementing transformers; (c) as booster sets and in the station; (d) as auxiliary power generators independent of steam or electric accidents in the main station; (e) co-operating on the main load as auxiliary stand-by, as peak or as base-load units working with steam or hydraulic turbines of larger capacity.

With all the aid of gas-engine experience as to design and construction of parts subjected to heavy gas pressures, and the protection of such parts as are exposed to heat of combustion, the modern oil-engine development may be said to have started with recognition of the fact that it should not be a mixture engine, but that for high efficiency with fuel oils it must be an injection engine. It did, however, take a long time to discover means of accomplishing such injection and subsequent combustion of fuel oils in a satisfactory way, and even now novelties are still being discovered and commercialized.

Systems of Oil Injection

The first commercial solution growing out of the efforts of Diesel provided for air compression above ignition temperature to insure ignition and also high efficiency, but it also provided for gradual introduction of fuel oil at a mechanically controlled rate to produce non-explosive combustion without any material rise of pressure that would require heavier parts, and at the same time without any material fall of pressure that would lower efficiency. This process is now called the Diesel cycle and engines working according to it, Diesel engines—names that will probably be permanent. To execute this process, Diesel proposed two different mechanical means of feeding the oil to the cylinder. One of these used a supercompressed air supply to blow a previously metered oil charge from the spray valve into the cylinder, the fuel flow rate depending on the speed with which the air could tear off the oil from the metal surfaces of the spray valve. This is now one of the modern standards for engines under the name of air-injection Diesel engine and as yet has no superior for the largest engines. The other Diesel way of injecting oil at the desired rate was more purely mechanical, dispensing with the compressed air. This also has become one of the modern standards for engines, under the name of solid-injection Diesel engines, though "airless" is sometimes used in place of "solid," as a word to distinguish it from the former.

Solid-Injection Engine a Late Development

The solid-injection Diesel engine, while originally suggested by Diesel as an idea, was not reduced to commercial form by him or by anyone else till comparatively recently. This development is the present outstanding feature in the oil-engine division of internal-combustion engine activities. It is the direct result of a conscious effort to simplify the air-injection Diesel engine so that its cost would not be prohibitively high in smaller sizes, where expensive attendance is not feasible, and where the cost per horsepower of air-injection Diesel engines was larger than in large sizes. There are several typical solutions of this problem, each represented by one or more, sometimes several, examples of engines in the commercial field of small or rather medium-sized oil engines with constant efforts to expand sizes both ways up into the zone of the air-injection Diesel and down toward that of the gasoline engine.

Other Oil-Engine Designs

In addition to the varieties of Diesel oil engine and its typical fuel-oil treatment, both air and solid injection, with ignition, by high compression only and graduated non-explosive combustion of fuel, with small changes of pressure, there has been another line of development leading to other varieties that should be classed as non-Diesel injection oil engines to distinguish them. These all are characterized by a material rise of pressure during combustion, the result of explosive combustion of a mixtuure formed before it is ignited, or of a rapid substantially instantaneous injection of fuel into air, usually put into violent motion by the shape of the chamber, the fuel burning so fast as to produce effects similar to an explosion.

Passing over the engines that use so low a compression as to need an ignitor, and classified as "hot-wall non-Diesel," the modern substitute is a cold-wall engine of high compression without an ignitor, and is characterized by explosive-type combination.

Oil Engine Can Compete with Steam Power

In larger sizes, especially for electric generation, the controlling factor in use is cost of power. Analysis of power-cost competition shows that the high efficiency of the oil engine makes it able to compete with steam at fuel prices that are higher on the B.t.u. basis, when the installation is not too large. This is due to the fact that other operating disbursements for labor and material are somewhat lower than for steam plants for corresponding sizes, and while the investment fixed charges are higher, the net favors oil engines below some size and steam above that size. The local conditions, including load, will determine the size, and in general this competitive size is rising for electric generation, pumping and for general power purposes.

Large Diesels for Marine Service

The influence of the successful motorship oil-engine design in general has been marked. Long experience at sea with engines of standard design has established proof of reliability, and low operating costs compared with steam constitute the most convincing evidence in favor of increased use of oil engines for stationary purposes. In addition it has resulted in a definite demand for marine engines of large horsepower, the meeting of which will force the solution of the many problems of larger cylinders. This demand, furthermore, seems to be leading directly toward the double-acting oil engine which clearly utilizes the heavy metal structure without any added stresses and which should contribute to lower costs per horsepower, especially if worked out in the two-cycle form.

Water-Power Neutral Zones Proposed for Quebec

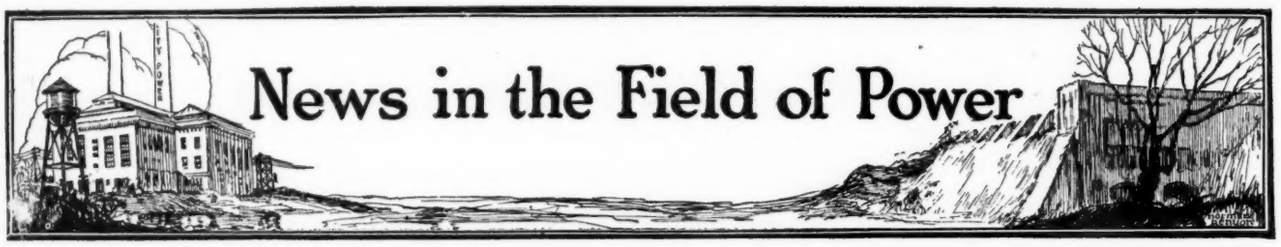
Quebec, having potential water power more than 100 times sufficient for its native industries, should establish neutral zones in the neighborhood of important water-power sources where American capital, after developing the water power, could establish industries, importing such machinery and raw materials as they may require from the United States free of customs duty and shipping the finished products to the United States, declared Athanase David, Provincial Secretary, recently in a speech, according to the *Christian Science Monitor*.

If the American industries established in these neutral zones sold their products in Canada, we would expect them to pay the Canadian duties, Mr. David added.

Quebec's chief assets are its water power and its forests, but Canada lacks sufficient capital to develop their economic possibilities to the fullest extent, the provincial secretary pointed out.

Quebec would secure first, capital; second, the development of water power; third, the establishment of important paper-producing centers which would give employment to many sons of the Province and stop the exodus to the United States.

Whether American capital would be induced to establish in these neutral zones other industries than paper making would depend on whether they were able to produce economically enough to sell their products in the United States in the face of the custom tariff, if the American Government would not permit the free access to its markets of products from these neutral zones but not now on the free list.



American Engineer Delegates to Power Conference Honor Memory of Trevithick

Visit Graveyard Where He Was Buried and Place a Wreath Upon a Tablet Erected to His Memory

ONE of the interesting and appropriate visits paid by the American engineers attending the World Power Conference at Wembley, England, was to the churchyard at Dartford, Kent, where nearly a century ago Richard Trevithick, the great engineer of steam-propelled vehicles and designer of the first practicable locomotive, who died in great poverty, was buried.

The visit was made to honor his memory and to place a wreath on the memorial tablet erected to him by Everard Hesketh, which is in the Parish Church. His grave was unmarked and cannot be definitely located.

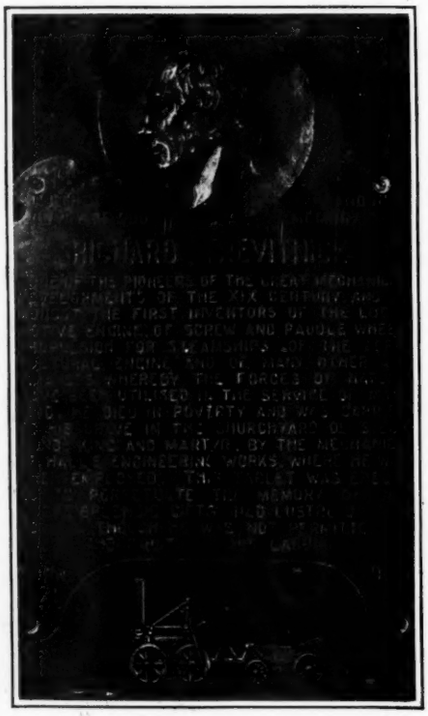
The party included R. C. Beadle, E. Kilburn Scott, John Hunter and Mrs. Hunter, Frederick D. Herbert, Walter G. Farr, Edwin Jowett and Mrs. Jowett, William M. White, Walter Springe and Mrs. Springe, James T. Hutchings and Mrs. Hutchings, Mrs. Fred R. Low and Miss Marguerite Walters. There were also present Everard Hesketh, W. A. Dixon, J. B. Walton, Mr. Ward, Mr. and Mrs. Botten and E. C. Youens.

Luncheon was served at Messrs. Vickers' Works on the invitation of Mr. Dixon, and a résumé of the life of Trevithick was given by Mr. Botten.

Mr. Hesketh of J. and E. Hall's, Ltd., the firm with which Trevithick was connected at the time of his death, gave some particulars of his unavailing efforts to locate the actual grave of the engineer, which was unmarked at the time of burial and among the graves of poor of the parish. He also told of Trevithick's connection with the firm of J. & E. Hall while developing the steam engine. He said that he believed that Trevithick made the first steam turbine there, but although he had searched, he could find no details of it.

Mr. Herbert voiced the feelings of the visitors, saying that they owed a deep debt of gratitude to those who had arranged the visit. On such an occasion they dropped engineering for a time and came no longer as cousins, but as brothers. They had the same standards and were all working for uniformity. It was in that spirit they had come to England. The Conference had been arranged, firstly for commercial purposes, secondly for professional purposes, but greater than all, for kinship sake, and to this end they came to Dartford to do honor to Trevithick.

Mr. Beadle said that Mr. Low, president of the A.S.M.E., who was unable to be with them, would have said more about kinship. Their visit in Trevithick's honor meant more than appeared on the surface and brought them all closer together. They were all troubled with politics, though interested in the forward movement.



Tablet to Richard Trevithick in Dartford, Kent, Eng.

He wished they could divorce the interests of politics from the doings of things for the people. That way would they solve the problems of peace and war.

The party then visited the Works and the Parish Church, where a wreath was placed on the tablet in Trevithick's memory by Mrs. Fred R. Low, who remarked how greatly her husband regretted being unable to be present.

Mr. Herbert said he felt impressed by the simplicity and early struggles of Trevithick. They might have accomplished much, but they saw that day how the great things of the world came up from simple beginnings.

Bituminous Coal Research Committee Named

With the idea of developing means and methods that will eliminate waste in the burning of bituminous coal, with the idea of reducing the smoke nuisance, and with the idea of making bituminous coal a more desirable domestic fuel, the National Coal Association has appointed a research committee to go into those problems. In connection with the work the committee will do, the National Coal Association will issue a printed booklet dealing with the problems of combustion.

Public Utilities Show Better Earnings

Gross earnings of the United Gas & Electric Corp. and subsidiaries for the month of June, 1924, were $1,142,936, as compared with $1,082,080 for June, 1923, an increase of $60,854. Net earnings for the month were $375,168 against $339,928 for the corresponding month in 1923, a gain of $35,240.

Other utility reports recently published included the following:

Associated Gas & Electric gross earnings for June, 1924, were $307,-159, as compared with $259,945 in 1923. The twelve months' gross was $3,519,-336 as compared with 1923, which was $2,848,012; the Los Angeles Gas & Electric gross earnings for June, 1924, were $1,044,327 whereas the June, 1923, gross earnings were $835,273 and the gross earnings for the twelve months were $14,069,875 as compared with $12,003,891 for 1923.

Boiler on Farm Tractor Explodes

The boiler of a farm tractor, being operated on the farm of W. R. Donavan near Cairo, Ohio, exploded on July 29, killing four workmen.

The boiler was said to have been of an old type and was being used cooperatively by a number of farmers. It is not known whether it had been inspected before firing it for the first time on July 26.

The boiler was hurled 800 ft. by the blast and landed in a corn field. It completely wrecked an auto parked near it, leaving only the radiator and twisted parts of the engine.

The sole surviving member of the operating crew, who was standing on the platform back of the boiler, was hurled 30 ft. He said that the gage had registered 120 lb. just before the explosion. An investigation is being made to fix the responsibility, according to press reports.

Power Machinery Exports to Spain Increase

The Department of Foreign and Domestic Commerce reports that exports of mining, oil-well and pumping machinery from the United States to Spain rose from a value of $154,167 in 1922 to $406,119 in 1923.

Shipments of construction and conveying machinery increased from $84,138 in 1922 to $115,422 in 1923. This gain took place in spite of a drop of over $28,000 in American exports of steam and other power shovels included in that classification. Exports of cranes increased from practically nothing in 1922 to nearly $20,000 in 1923.

A drop of nearly $70,000 occurred in exports of power-generating machinery in 1923.

The following table gives the United States exports of pumping, power generating and construction and conveying machinery to Spain for the years 1922 and 1923.

Pumps	1922	1923
Centrifugal pumps	1,361	1,451
Steam pimps	10,821	13,786
Other power pumps	8,793	13,057
Power-generating machinery, except electric	$161,129	$94,977
Construction and conveying machinery	84,138	115,422

Salesmanship along conservative lines, dependent on current market conditions, should result in increased sales of American machinery to Spain in 1924, is pointed out by the department.

Smith Says Cost of Fuel Oil Is Making British Shipping Revert to Coal

Geological Survey Head Back from Power Conference—Tells of Development of Liquid Fuel with Coal as Base

THE wide difference between the cost of fuel oil and the cost of coal is resulting in the reconversion of many ocean carriers to the use of coal. This was one of the significant trends which Dr. George Otis Smith, the Director of the United States Geological Survey, observed in Europe. Dr. Smith has just returned from London where he represented the Secretary of the Interior at the World Power Conference, which was held at Wembley, England, from June 30 to July 12.

Another development that has much significance for coal, he points out, is the progress being made in the production of a liquid fuel with coal as the base.

"A power conference held in Great Britian," declares Dr. Smith, "naturally puts emphasis on coal. As I mentioned at one of the sessions of the World Power Conference, commerce in power already is an international matter. When consideration is given to the number of wheels throughout the world that are turned by British coal and by American oil, there is a greater appreciation of that fact. I saw electrical energy derived from British coal and from Swedish waterfalls at work in connection with the operation of Danish farms. This example is typical of the use of power which takes on an international character.

"I saw evidence that British shipping, at least, is trending away from oil as a marine fuel, because the cost of coal is relatively so much lower. The price level of fuel oil was characterized as being 'totally unwarranted.' I was told that fuel oil was selling at Mediterranean ports at 87s. 6d. per ton as against 35 shillings for coal. Bunker coal was obtainable at United Kingdom ports, I was advised, at 20 shillings. Some oil-burning ships already have been reconverted to coal. Apparently, this is prophetic of what surely will take place more generally at some time in the future unless economic processes are developed for using coal as the source of a liquid fuel.

"It is significant that so strong an interest as The Vickers is giving attention to processes for treating coal as the raw material in the manufacture of fuel in more convenient forms," he further states.

Great Britain to Distill Its Coal

The Nottingham Corporation, according to current press reports, has entered into a contract with the Low Temperature Carbonisation, Ltd., which already has a big plant at Barnsley in Yorkshire, to supply 2,000,000 cu.ft. of gas a day which is to be increased later to 6,000,000. A plant is to be set up at Nottingham which will be capable of dealing with 1,000 tons of coal a day. From this will also come some 3,000 gal. of benzole and 6,000 gal. of Diesel oil. The smokeless fuel known as coalite will be one of the byproducts from which will be extracted also cresylic acid, lubricating grease, and residues that are of value in various trades.

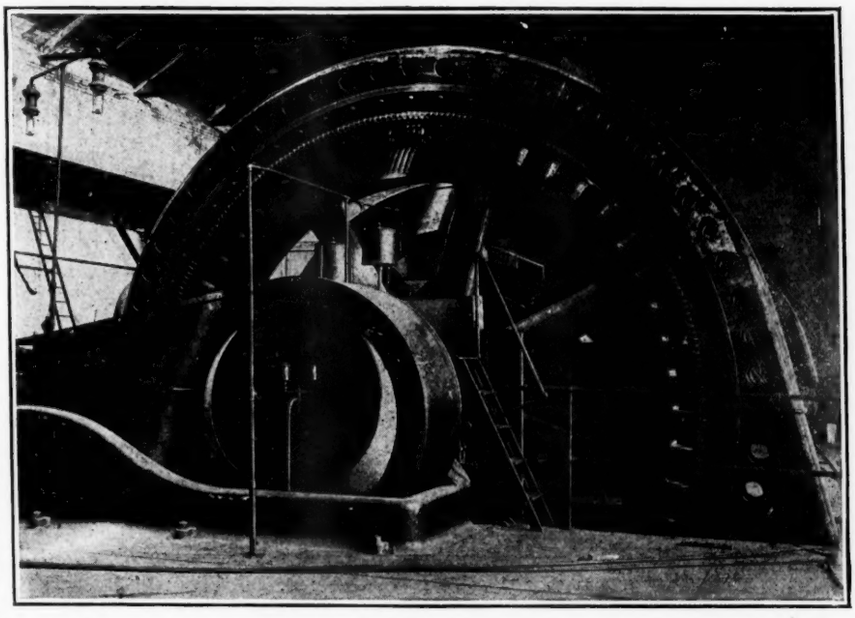
The experts estimate that if the 20,000,000 tons of coal at present used to produce gas were treated by the low-temperature process, some 60,000,000 gal. of benzole and 30,000,000 gal. of fuel oil would be produced in addition to large quantities of smokeless fuel. This coalite, as it is called, is superior to coke, as it will burn by itself in an ordinary grate with a glowing heat without flames. Archibald Hurd, the well-known writer on naval matters, drew attention last year to the wasteful way in which Great Britain used her coal resources by not distilling her coal instead of merely burning it in the raw state.

Old Induction-Alternators Help Meet Power Shortage

A modern community in need of power is not interested in the type of equipment that generates it. To the engineer, however, the accompanying photograph of a Stanley inductor-alternator brings back memories of years gone by. This machine with another one like it and three Bullock inductor-alternators, were recently placed in operation in the old Seventh and Central Street steam plant of the Southern California Edison Co., to help meet the shortage of hydro-electric power in southern California caused by the driest year in the history of the state. This is one of many obsolete plants that have been rehabilitated and pressed into service. The equipment here was installed some twenty-two years ago, and the plant has been idle for the last eleven years.

The machines are rated at 1,500 kw. 2,300 volts 50 cycles, and each is driven by a cross-compound engine.

It is a strange coincidence that C. H. Hagey, one of the operators in the station twenty years ago, should again be operating the plant.



Steam plant of the vintage of about 1902 *goes into operation in Los Angeles*

Hydro-Electric Development in France

The French ministry of public works has announced that as of Jan. 1, 1924, the hydraulic electric power harnessed in France amounted to 2,400,000 hp. Of this amount, 2,250,000 hp. operates electric generators; 37 per cent of that total, or 850,000 hp., is used by electrochemical and electrometallurgical industries, according to government reports.

Ericsson Memorial Tablet Unveiled July 31

Commemorating the 121st anniversary of the birth of Captain John Ericsson, the great Swedish inventor of American adoption, who by his invention of the "Monitor" revolutionized naval warfare and ship construction, a memorial tablet was erected at 95 Franklin St., New York City, on July 31. It was at this address that he designed and built the model of the ironclad in 1861. The tablet was also raised as a memorial to John A. Griswold, Cornelius S. Bushnell and J. F. Winslow, whose financial and technical aid helped Ericsson greatly in the evolution of his plans.

Ericsson was particularly interested in steam engines, and no one did more for the development of steamship propulsion than he. He patented an air compressor for pumping and a centrifugal blower, and he built the first steam fire engine for London, but London preferred pumping by hand at that time. In his last years he was occupied with motors and storage of motive power.

The ceremony was held under the direction of the National Museum of Engineering and Industry, Washington, D. C. The tablet, which was executed by Anton Schaff, was presented by E. J. F. Porter on behalf of the descendents of Bushnell, Winslow and Griswold.

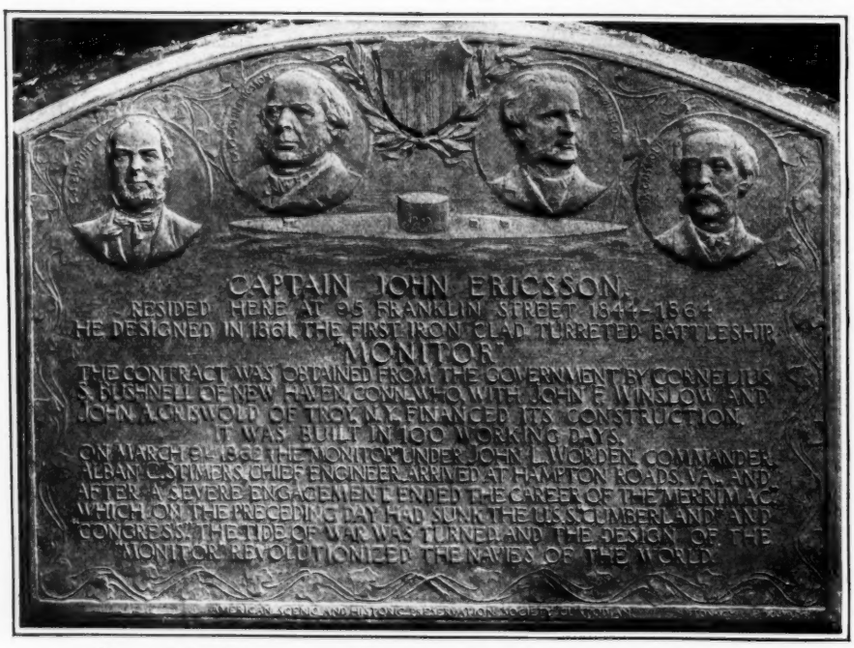
Lack of Coal Statistics Hampers Industry

Economists, public and private, are giving an unusual amount of study to the problems of coal. The industry is passing through its worst depression.

An example of the benefits to the industry which are resulting from the depression, however, is the elimination of the uneconomical mine. These mines are going on the bargain counter in increasing numbers at prices that thoroughly justify the statement that they are being sold for a song. In that connection, however, it is pointed out that there is nothing strange in the sale of coal mines at such sacrifices when the spot price is lower than at any time since 1916. When account is taken of the various wage advances that have taken place since 1916, the unremunerative character of the present coal price is accentuated.

One of the great difficulties in the operation of the coal industry is the lack of fundamental information. A large amount of the data gathered by the local associations and on a national scale are not now available. The situation is serious because there never was a time that the coal industry had the statistical guidance essential to its thoroughly intelligent conduct, but the volume of statistics formerly available constituted a veritable plethora of essential data as compared with that available now. The outstanding crying need of the industry, however, is for a stock report. Among the operators the feeling is that stocks are much lower than is indicated by the various guesses being made. When the fundamental importance of coal is considered, it would seem, many point out, that the greatest industrial nation in the world would have available information of this importance. Statistics are most needed in troublesome times. In actual practice, however, the coal industry produces its greatest amount of statistics when they are least needed, and when they are greatly needed the available figures are almost negligible.

Enough data are available, however, to determine the fact that the state of industry is not alone responsible for the decrease in the volume of consumption. Better utilization of coal is a more important factor than is generally realized. No small amount of coal has been displaced by fuel oil, and some reduction in the amount of coal required has resulted from the elimination of small isolated power plants with the growing availability of electricity. Some further losses of coal market are attributable to the development of hydro-power.


CAPTAIN JOHN ERICSSON
RESIDED HERE AT 95 FRANKLIN STREET 1844-1864
HE DESIGNED IN 1861 THE FIRST IRON CLAD TURRETED BATTLESHIP
"MONITOR"
THE CONTRACT WAS OBTAINED FROM THE GOVERNMENT BY CORNELIUS S. BUSHNELL OF NEW HAVEN, CONN. WHO, WITH JOHN F. WINSLOW AND JOHN A. GRISWOLD OF TROY, N.Y. FINANCED ITS CONSTRUCTION.
IT WAS BUILT IN 100 WORKING DAYS.
ON MARCH 9, 1862 THE MONITOR UNDER JOHN L. WORDEN, COMMANDER, ALBAN C. STIMERS, CHIEF ENGINEER, ARRIVED AT HAMPTON ROADS, VA., AND AFTER A SEVERE ENGAGEMENT, ENDED THE CAREER OF THE MERRIMAC WHICH, ON THE PRECEDING DAY, HAD SUNK THE U.S.S. "CUMBERLAND" AND "CONGRESS." THE TIDE OF WAR WAS TURNED AND THE DESIGN OF THE "MONITOR" REVOLUTIONIZED THE NAVIES OF THE WORLD.
AMERICAN SCENIC AND HISTORIC PRESERVATION SOCIETY, INCORPORATED

Memorial tablet erected to memory of Ericsson by descendents of Bushnell, Winslow and Griswold

Addition to Swedish Water-Power System

The Riksdag of Sweden has recently authorized the construction of a new water-power system at Norrforsen on the Ume River. According to reports received by the Bureau of Foreign and Domestic Commerce, the plans being prepared by the Water Power Commission provide for the construction of a 12,000-kw. plant.

Production of Electricity Steadily Decreases

The average daily production of electricity by public-utility power plants in June was 152,600,000 kw.-hr., about 1 per cent less than the daily output for the month of May. The curve of average daily total output for 1924 indicates that the production of electricity by public-utility power plants for the first half of the year has steadily decreased since January. The average rate of output for May and June clearly indicates that there has been more than the usual seasonal decline in demand for electricity during these two months.

The output for June of this year was only a little more than 1 per cent greater than the output for the corresponding month in 1923. No indication of the trend for the remaining half of the year will probably be available until the output for August has been determined, as the output for July, judging from records of previous years, is subject to a peculiar decrease for which there is no apparent explanation. This pecularity in the July figures of output renders them of little or no value in indicating the trend of demand for electricity. The curve of average daily output by the use of water power shows that the output of electricity by the use of water power reached a maximum for the year in May.

The average daily production of electricity by public-utility power plants and the proportion produced by water power for each month of this year were as follows: January, 167,400,000 kw.-hr. 32.3 per cent by water power; February, 166,700,000 kw.-hr. 32.3 per cent by water power; March, 160,800,000 kw.-hr. 34.4 per cent by water power; April, 158,100,000 kw.-hr. 39.2 per cent by water power; May, 154,600,000 kw.-hr. 40.8 per cent by water power; June, 152,600,000 kw.-hr. 38.5 per cent by water power.

Morwell-Yallourn Plant Under Steam

It is expected that a certain amount of power from the Morwell-Yallourn plant will soon be available for use in Melbourne. The initial unit of generating plant is already under steam; drying out operations and electrical adjustments are now in progress, according to *Commerce Reports*.

Personal Mention

Arthur C. Hobble, after several months leave of absence is returning to his position as chief engineer in charge of the Ebro Irrigation & Power Co., Apartado 491, Barcelona, Spain.

J. F. Jones, vice-president of Chas. Cory & Son., Inc., New York, sailed for Europe on August 2 aboard the Steamship George Washington to attend the British Empire Exposition at Wembley. While abroad, Mr. Jones will also investigate marine and industrial business conditions in England and on the continent.

Business Notes

The Scott Valve Manufacturing Co., Detroit, Mich., reports that H. L. Woolfenden has joined the company and will have charge of sales promotion.

Neemes Foundry, Inc., 41 Adams St., Troy, N. Y.; manufacturers of grates, is the new corporate name of the firm formerly known as Neemes Brothers, Inc.

The McClave-Brooks Co., Scranton, Pa., announces that after Aug. 1 its branch office in St. Paul will be closed and the territory covered by the Chicago office.

The De Laval Steam Turbine Co., Trenton, N. J. will be represented by the Wm. Constable Co., Providence Bldg., Duluth, Minn., in parts of Minnesota, Wisconsin and Michigan. This change is brought about by the Constable company having bought out the H. J. Rich Co., the former representative.

Warren Webster & Co., Camden, N. J., manufacturers of feed-water heaters, steam traps, etc., are opening two new branches, one at Butte, Mont., and the other at Albany, N. Y. The Butte office is at 223 North Main St. and is under the direction of T. L. Sullivan; the Albany office is at 28 South Pearl St. and is under the charge of Horace A. Bond.

Trade Catalogs

Conveyors, Belt—The Brown Hoisting Machinery Co., Cleveland, Ohio. Catalog M-24 describes in detail these conveyors and gives tables of power requirements, dimensions, width of belt, etc. It is well illustrated with photos and working drawings.

Motors, Synchronous—Electric Machinery Manufacturing Co., Minneapolis, Minn. Bulletin No. 854 "Synchronous Motors for Compressors," gives illustrations of installations, descriptions, and a table of power and speed ratings. Bulletin No. 785 gives a list of some of the users of E-M synchronous motors and vertical alternators manufactured by this company.

Packing—Kneadable Metallic Packing Co., 780 Bryant St., San Francisco, Calif. Leaflet describing the merits of "U-Knead-it" a metallic packing suitable for water, steam, oil, tar acids, etc.

Pipe—National Tube Co., Pittsburgh, Pa. The "National" pipe for power plants is the subject of National Bulletin No. 10, which is well illustrated and which takes up the subjects of uniformity, physical properties, ductility, welding and threading qualities, durability, tests and the special uses of this pipe. Many useful tables of specifications, weights, dimensions, test pressures, flanged fittings, pipe bends, properties of saturated steam, and charts of flow of steam, etc. are included.

Coming Conventions

American Ceramic Society. Ross C. Purdy, Lord Hall, Ohio State University, Columbus Ohio. Convention at Los Angeles, Calif., Oct. 6-7.

American Chemical Society. Dr. Charles L. Parsons, 1709 G St., N. W., Washington, D. C. Sixty eighth meeting at Cornell University, Ithaca, N. Y. Sept. 8-13.

American Electric Railway Association. James W. Welsh, 8 West 40th St., New York City. Meeting at Atlantic City, Oct. 6-10.

American Electrochemical Society. Dr. Colvin G. Fink, Columbia University, New York City. General meeting at Detroit, Mich., Oct. 2-4.

American Institute of Electrical Engineers. F. L. Hutchinson, 29 West 39th St., New York City. Fall convention at Pasadena, Calif., Oct. 13-17.

American Institute of Mining and Metallurgical Engineers. F. F. Sharpless, 29 West 39th St., New York City. Autumn meeting at Birmingham, Ala., Oct. 13-15.

American Society of Civil Engineers. 29 West 39th St., New York City. Fall meeting at Detroit, Oct. 23-25.

American Society of Mechanical Engineers. Calvin W. Rice, 29 West 39th St., New York City. Annual meeting at New York City, Dec. 1-4.

American Society of Refrigerating Engineers. W. H. Ross, 35 Warren St., New York City. Annual meeting at New York City, Dec. 1-3.

Association of Iron & Steel Electrical Engineers, John F. Kelly, 1007 Empire Bldg., Pittsburgh, Pa. Annual meeting and exposition at Duquesne Garden, Pittsburgh, Pa., Sept. 15-20.

Eastern Ice Manufacturers Association. W. H. Ross, 35 Warren St., New York City. Eighteenth annual meeting at Hotel Chelsea, Atlantic City, N. J., Nov. 12-14.

Exposition of Inventions. American Institute, 47 West 34th St., New York City. Exposition to be held in the Engineering Societies Building, 29 West 39th St., New York City, Dec. 8-13.

Franklin Institute of Pennsylvania, Centenary Celebration at Philadelphia, Sept. 17-19.

Illuminating Engineering Society. Norman D. MacDonald, 29 West 39th St., New York City. Convention at Briarcliff Lodge, Briarcliff Manor, N. Y., Oct. 27-31.

International Union of Steam and Operating Engineers. Dave Evans, 6334 Yale Ave., Chicago, Ill. Biennial convention at Detroit, Mich., Sept. 8-13.

National Association of Practical Refrigerating Engineers. E. H. Fox, 5707 West Lake St., Chicago, Ill. Convention at New Orleans, La., Nov. 11-14. Exhibits at the Isaac Delgado High School.

National Association of Stationary Engineers. Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual convention and exhibition at Hotel Pantlind, Grand Rapids, Mich., Sept. 8-13. Annual conventions and exhibitions of the state associations are scheduled as follows: **Michigan Association** at Grand Rapids, Sept. 8. Wm. H. Yeomans, 209 Plainfield Ave., Grand Rapids. **Pennsylvania State Association** at Grand Rapids, Mich., Sept. 8. J. N. Calvert, Union & Ridenour Ave., Crafton, Pittsburgh, Pa.

National Exposition of Power and Mechanical Engineering. C. F. Roth, Grand Central Palace, New York City. Annual exposition at New York City, Grand Central Palace, Dec. 1-6.

National Safety Council, W. H. Cameron, 168 N. Michigan Ave., Chicago, Ill. Thirteenth Annual Safety Congress at Louisville, Ky., Sept. 29 to Oct. 3.

New England Water-Works Association, Frank T. Gifford, 715 Tremont Temple, Boston, Mass. Annual convention at Powers Hotel, Buffalo, N. Y., Sept. 23-26.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	July 28, 1924	Aug. 4, 1924
Pool 1	New York..	$2.50@2.90	$2.50@2.90
Smokeless	Columbus..	2.00@2.25	2.00@2.25
Clearfield	Boston	1.45@2.30	1.45@2.35
Somerset	Boston	1.65@2.40	1.75@2.40
Kanawha	Columbus..	1.35@1.60	1.30@1.60
Hocking	Columbus..	1.60@1.80	1.45@1.65
Pitts. No. 8	Cleveland..	1.80@1.90	1.80@1.90
Franklin, Ill.	Chicago	2.25@2.50	2.25@2.50
Central, Ill.	Chicago	2.00@2.25	2.00@2.25
Ind. 4th Vein	Chicago	2.25@2.50	2.25@2.50
West Ky.	Louisville..	1.50@1.75	1.40@1.65
S. E. Ky.	Louisville..	1.35@1.75	1.35@1.75
Big Seam	Birm'g'h'm	1.50@2.00	1.50@2.00

FUEL OIL

New York—July 31, light oil, tank-car lots, 28@34 deg. Baumé, 4⅜c. per gal., 36@40 deg. 5¼c. per gal., f.o.b. Bayonne, N. J.

St. Louis—July 15, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.55 per bbl.; 26@28 deg., $1.60 per bbl.; 28@30 deg., $1.65 per bbl.; 30@32 deg., $1.75; 32@36 deg., gas oil, 4.5c. per gal.; 38@40 deg., 5.5c. per gal.

Pittsburgh—July 24, f.o.b. local refinery, 30@40 deg., fuel oil, 5c. per gal.; 36@40 deg., fuel oil, 5¼c. per gal.; 34 deg., neutral, 8½c. per gal.

Dallas—July 28, f.o.b. local refinery, 26@30 deg., $1.25 per bbl.

Philadelphia—July 18, 28@30 deg., $2.05@$2.113 per bbl.; 18@22 deg., $2.075@$2.139; 13@16 deg., $1.78½@$1.848 per bbl.

Boston—Aug. 4, tank-car lots, f.o.b. heavy oil, 12@14 deg. Baumé, 4¾c. per gal., light oil, 28@32 deg. Baumé, 6¾c. per gal.

Cincinnati—July 28, tank-car lots, gal., light oil, 28@32 deg. Baumé, 4⅜c. per gal.; 26@30 deg., 4½c. per gal., 30@32 deg., 5c. per gal.

Chicago—July 22, 20@22 deg., 5½c. per gal.; 24@26 deg., 6c. per gal.; 28@30 deg., 6½c. per gal.

New Plant Construction

Ala., Florence—The U. S. Engineer's Office, War Dept., Washington, D. C., will receive bids until Aug. 28, for furnishing and delivering 24 headgate operating rigs for the power house at Wilson Dam, Tennessee River.

Ariz., Casa Grande — The City Council awarded the contract for one 200 hp. semi-diesel oil engine driven generating set, to be delivered and installed, to Jules L. Vermeersch, 27 South Central Ave., Phoenix.

Ariz., Gila Bend—Jules L. Vermeersch, 27 South Central Ave., Phoenix, has purchased the light and power plant here and will be in the market for a semi-diesel engine, alternator and pole line equipment.

Calif., Aptos—The City plans to develop the water supply in Dee Park Villa Tract, including sinking of two wells, installing pumps and building pipe lines. Townsend, Ambler & Zaagma, Aptos, are engineers.

Calif., Los Angeles — The California Lutheran Hospital, 1414 South Hope St., has retained Walker & Eisen, architects, Great Republic Bldg., to prepare plans for a group of hospital buildings on 15th and Hope Sts., to include a 50 x 80-ft. power house. Project to cost approximately $1,000,000.

Calif., Sacramento—The Supervisors of Sacramento County are receiving bids for a concrete, brick and steel power house and laundry on the hospital grounds. Estimated cost $90,000. R. A. Herrold, Forum Bldg., Sacramento, is architect.

Calif., San Francisco—St. Mary's Hospital, Grove and Stanyan Sts., is having plans prepared by Shea & Shea, architects, Chronicle Bldg., for a group of hospital buildings on Stanyan St., to include a laundry building. Estimated cost $500,000.

Calif., Santa Maria—The Santa Maria Irrigation District is having plans prepared for an irrigation project comprising approximately 50,000 acres of land. Plans include large storage dam and canal system. Estimated cost between $3,500,000 and $4,000,000. Charles Polk, Santa Maria, consulting engineer.

La., Cheneyville — The Town plans to construct an electric light and water plant. Estimated cost $40,000. F. P. Joseph, Glenmora, consulting engineer.

Mass., Boston—The Department of Public Works, City Hall, will receive bids until Aug. 12, for furnishing and installing electric valve operating equipment on 36 in. valve at Copley Sq., Beacon St. and Commonwealth Ave., Huntington Ave. at South Huntington Ave., for water service. J. A. Rouke, commissioner.

Miss., Brookhaven—The City voted $50,000 bonds for improvements to the electric light and water plant.

Mass., Medfield—The Commonwealth of Massachusetts, Dept. of Mental Diseases, Boston, will construct a 1-story, 80 x 200 ft. laundry building at Medfield State Hospital, Medfield Junction. Estimated cost $200,000. Kendall Taylor & Co., 142 Berkley S., Boston, are architects.

Mass., Springfield—The City plans to install sewers and a pumping station in Entry Dingle Heights District. Estimated cost $55,000. Address Department of Public Works.

Minn., Owatonna—The City has awarded the contract for an electric disrtibution system, street lighting system, power plant, etc., to the Donovan Construction Co., St. Paul, Minn., for $263,000.

Miss., Vicksburg—J. M. Dutton, Vicksburg, and J. L. Blackman, and M. G. McGary, Jackson, plan to build an ice plant here, to be driven by electricity.

Neb., Lincoln — The Nebraska Gas & Electric Co., Standard Oil Bldg., Omaha, plans to construct a transmission line from here to Plattsmouth, also build a substation. Estimated cost $500,000. W. M. Jackson is engineer.

Neb., Swedeburg—The City plans an election to vote on $65,000 bonds for municipal light plant and distribution system. Address City Clerk.

N. H., Keene—The City is having preliminary plans prepared by Weston & Sampson, engineers, 14 Beacon St., Boston, Mass., for two filtration plants and reservoir; one plant on main from Stone Dam and one on main from Quarry Hill; reservoir to be located on Beech Hill.

Okla., Bethany—The City plans to install a new water system to include deep well pump, Estimated cost $40,000. Macintosn Co., First National Bank Bldg., Oklahoma City, are engineer.

Every one of these items is reported by our authorized correspondents who are instructed to verify every item sent in. This free weekly service is published in the interests of the buyer and the seller, to bring them together and get machinery moving.

Everything possible is done to insure authenticity and timeliness.

Your co-operation is invited in helping us maintain this service at the highest efficiency.

BUSINESS NEWS DEPARTMENT
Tenth Ave. at 36th St., New York

S. D., Virgil—The Town has awarded the contract for a waterworks system, including a 35,000 gal. reinforced-concrete reservoir, frame pumping station and centrifugal pump, to Ellerman & McLain, Yankton.

Tex., Crawford—The City will hold an election Aug. 18 to vote on $25,000 bonds for improvements to the water-works, including a larger pumping plant. F. V. Broach, Mayor.

Tex., Edinburg—Hidalgo County plans to develop 40,000 acres in Water Improvement Dist. No. 4. Water to be lifted up 40 ft. out of Rio Grande River and pumped into 400 acre reservoir and then to flow by gravity through irrigation canals. County will purchase three 750 hp. engines, three 42 in. centrifugal pumps, etc. Estimated cost $500,000. W. L. Rockwell, Edinburg, is engineer.

Tex., Ft. Worth—The Arlington Ice Co., Arlington, will build an ice plant and refrigeration plant on 5th Ave. and 4th St., here, by day labor. Estimated cost $100,000. Noted July 29.

Tex., Ft. Worth—The Rock Island Ice Co., 517 East First St., plans to construct an ice plant on East First St. Estimated cost $85,000. Charles G. Harrold, proprietor.

Tex., Port Arthur—J. R. Adams, owner, and H. C. Mauer, architect, 750 Spruce St., Beaumont, will receive bids until Aug. 18, for a 6 story, 114 x 140 ft. store and office building at 5th and Austin Sts., to include cold storage and refrigerator plant. Estimated cost $500,000.

Wash., Riverside—The Riverside Irrigation District has had plans prepared by the Miller Engineering Co., 605 Burke Bldg., Seattle, for a hydro electric power plant to develop 3000 hp. Bids for the plant, including concrete dam, concrete and steel power house and 15 mi. transmission line will be received until Aug. 23 by J. B. Williams, secretary of the District, Riverside. Estimated cost $250,000. Bond issue already voted for project.

Wash., Seattle — Aerie No. 1, Eagles Lodge, will soon award the contract for a 6 story, 120 x 175 ft. temple on 7th and Union Sts. Estimated cost $1,000,000. Henry Bittman, Securities Bldg., is architect.

Wash., Tacoma — The Masonic Grand Lodge of Washington plans to construct a Masonic Home near Tacoma. The first unit will include an administration building, power plant and water system and will cost approximately $400,000. Heath, Gove & Bell, P. S. Bank Bldg., Tacoma, are architects.

Wis., Chippewa Falls—Chippewa County, J. R. Harris, county clk., has awarded the contract for a brick and reinforced-concrete boiler plant to Shafer & Olson, 222 Bay St. Estimated cost $40,000.

Wis., Madison — The Madison Gas & Electric Co., c/o J. St. John, manager, 100 North Fairchild St., plans to build a brick, reinforced-concrete and steel electric generating plant, steam propelled.

Wis., Manitowoc—The Northern Wisconsin Produce Co., South 6th and Quay Sts., and the B. K. Gibson Co., engineers, 624 South Michigan Ave., Chicago, Ill., are receiving bids for a 2-story and 3-story brick and mill construction cold-storage plant. A 75 to 100 ton motor driven ice machine will be installed. Estimated cost $50,000.

Wis., Madison—The Kennedy Dairy Co., 629 Norh Washington Ave., is in the market for refrigeration machinery and equipment. E. Torgh, purchasing agent.

Wis., Middleton—The Valecia Milk Co., Washington Bldg., Madison, is having plans prepared for a 2-story, 30x42 ft. factory addition, here, including a refrigeration plant. Estimated cost $40,000. F. I. Kronenberg, Carroll Blk., Madison, is architect.

Wis., Milwaukee—R. Messmer & Bro., architects, 221 Grand Ave., are receiving bids for a 1-story, 36 x 60 ft. power house on State St., for Concordia College, 3127 State St. Project will include a 125 ft. brick chimney. Estimated cost $50,000.

Wis., New Holstein—The Town is having plans prepared for a sewage treatment plant consisting of 10-ft. clarifier, motors, pumps, etc. J. Donohue Co., Sheboygan, are engineers.

Ont., Forest—The Town is having plans prepared by James Bell & Son, engineers, Court House, St. Thomas, for a waterworks system, including pump house, electric pumps, etc. Estimated cost $100,000.

Ont., Port Arthur—The Hydro Electric Power Commission, 190 University Ave., Toronto, will have plans prepared for the construction of a brick, concrete and steel electric distributing station, here, to distribute power generated at Inpegon. Equipment, including motors, motor generators, insulators, switchboards, oil switches, etc., will be installed. Estimated cost $400,000. F. A. Gaby, c/o Commission, engi-

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

SINCE LAST MONTH

Electrical supplies continue to decline in price. This is especially noticeable in the rubber-covered copper wire. Drop of 10c. per 100 lb. in structural steel at New York warehouses since July 8. Linseed oil advanced 5c. per gal. for the 5 bbl. lots, New York. Babbitt metal, 83 per cent tin, now 58½c. per lb., Cleveland.

POWER-PLANT SUPPLIES

HOSE—Quotations at New York warehouses:

	Fire Protection	50-Ft. Lengths
Underwriters' 2½-in., coupled, sing'e jacket		56c. per ft.
Common, 2½-in., 3-ply	80c. per ft. list less	50–10%

Air—Best grade

¾-in., per ft.	3-ply $0 36	4 ply $0.44½

Steam—Discounts from List

First grade	Second grade	Third grade
30–5%	40–5%	50%

RUBBER BELTING—The following discounts from list apply to rubber transmission belting:

Best grade	Second grade
50%	50–10%

LEATHER BELTING—List price, 24c. per lin.ft. per inch of width for single ply at New York warehouses.

Grade	Discount from list
Medium	40–2½%
Heavy	30–5%

RAWHIDE LACING—For cut, best grade, 45–5%, 2nd grade, 55%. For laces in sides, best, 41c. per sq.ft.; 2nd, 37c. Semi-tanned: cut, 45–5%; sides, 41c. per sq.ft.

PACKING—Prices per pound at New York warehouses:

Rubber and duck for low-pressure steam, ⅛ in.	$0.90
Asbestos for high-pressure steam, ⅛ in.	1.70
Duck and rubber for piston packing	.90
Flax, regular	1.10
Flax, waterproofed	1.70
Compressed asbestos sheet	.80
Wire insertion asbestos sheet	1.30
Rubber sheet	.45
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.25
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.30
Asbestos wick, ½- and 1-lb. balls	50

PIPE AND BOILER COVERING—Discounts, New York warehouses, are as follows:

85% magnesia high pressure		50%
For low-pressure heating and return lines	4-ply	70%
	3-ply	72%
	2-ply	74%

PORTLAND CEMENT—New York, $2.50@ $2.60 per bbl. without bags, in carload lots delivered on job. Bag charge of 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, 3 to 15-in. beams and channels and 3 to 6-in. angles, tees, and plates, all $3.34 per 100 lb.

COTTON WASTE—The following prices are in cents per pound:

	New York	Cleveland	Chicago
White	14@21	20.00	14.00
Colored	9@14.50	17.00	10.50

WIPING CLOTHS—Jobbers' prices, in cents per lb., as follows:

	13½ x 13½	13½ x 20½
Chicago	16.00	16.00
New York (white, at washeries)	11.25	.....
Cleveland	$36.00 per M.	$52.00 per M.

LINSEED OIL—These prices are per gallon:

	New York	Cleveland	Chicago
Raw in barrels (5 bbl. lots)	$1.05	$1.09	$0.94

WHITE AND RED LEAD—In 100-lb. kegs, base price in cents per pound:

	Dry		In Oil	
	Current	1 Yr. Ago	Current	1 Yr. Ago
Red	14.50	14.00	16.00	15.50
White	14.50	14.00	14.50	14.00

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ⅞ and smaller	50%	60–10%	70%
Tinned	50%	60–10%	70%

Structural rivets, ½, ⅝, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.

New York	Chicago	Pittsburgh
$4.00	$3.75	$2.45@$2.50

Boiler rivets, same sizes:

New York	Chicago	Pittsburgh
$4.10	$3.85	$3.00

REFRACTORIES—Prices in car lots f.o.b. plant:

Chrome brick, eastern shipping points	net ton	$47@52
Chrome cement, 40@ 50% Cr_2O_3, in bulk	net ton	22@27
Chrome cement, 40@ 50% Cr_2O_3, in sacks	net ton	26@31
Magnesite brick: 9-in. straights	net ton	65@68
Magnesite brick: 9-in. arches, wedges and keys	net ton	71.50@74 80
Magnesite brick: Soaps and spits	per ton	91.00@95.20
Silica brick: Mt. Union, Pa.	per M	38@40
Clay brick, 1st quality, 9 in. shapes, Pennsylvania	per M	41@48
Clay brick, 1st quality, 9 in. shapes, Ohio	per M	40@43
Clay brick, 1st quality, 9 in. shapes, Kentucky	per M	42@43
Clay brick, 2nd quality, 9 in. shapes, Pennsylvana	per M	36@43
Clay brick, 2nd quality, 9 in. shapes, Ohio	per M	37@39
Clay brick, 2nd quality, 9 in. shapes, Kentucky	per M	37@39
Chrome ore crude, 40@50%	net ton	17.00@19.50

BABBITT METAL—Warehouse prices in cents per pound:

	New York	Cleveland	Chicago
(83% tin)	60.00	58.50	48@52
(35% tin)	28.00	17.50	23@26

COLD DRAWN STEEL—Warehouse prices are as follows:

	New York	Cleveland	Chicago
Round shafting and screw stock, per 100 lb. base	$4.15	$4.00	$3.80
Flats, square and hexagons, per 100 lb. base	4.65	4.50	4.30

BOILER SPECIALTIES—F. o. b. New York or Jersey City, discounts on list:

	Current
Copper ferrules	70%
Boiler flanges	60-10%
Boiler stay bolts	60%
Boiler patch bolts	10%
Boiler fitting-up bolts	45%
Pressed steel boiler lugs	10%
Pressed steel boiler hangers	10%

WROUGHT PIPE—The following discounts are to jobbers for carload lots on the latest Pittsburgh basing card:

BUTT WELD

Inches	Steel Black	Steel Galv.	Inches	Iron Black	Iron Galv.
1 to 3	62	50½	1 to 1½	30	13

LAP WELD

2	55	43½	2	23	7
2½ to 6	59	47½	2½	26	11
7 and 8	56	43½	3 to 6	28	13
9 and 10	54	41½	7 to 12	26	11
11 and 12	53	40½			

BUTT WELD, EXTRA STRONG, PLAIN ENDS

1 to 1½	60	49½	1 to 1½	30	14
2 and 3	61	50½			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	53	42½	2	23	9
2½ to 4	57	46½	2½ to 4	29	15
4½ to 6	56	45½	4½ to 6	28	14
7 and 8	52	39½	7 and 8	21	7
9 and 10	45	32½	9 to 12	16	2
11 and 12	44	31½			

BOILER TUBES—Following are prices in New York warehouse of tubes manufactured according to specifications of the American Society of Mechanical Engineers:

Size	Lapweld Steel	C. C. Iron	Seamless Steel
1	.....	.....	$0.23
1¼	.....	.....	.25
1½	.....	.....	.22
1¾	$0.26	$0.29	.23
2	.20	.25	.21
2¼	.23	.29	.23
2½	.24	.33	.28
2¾	.....	.....	.....
3	.30	.41	.32
3½	.32	.47	.35
3½	.34	.51	.37
4	.43	.64	.47

Tubes 2½ in. diameter, or smaller, over 18 ft. long, 10 per cent extra.

These prices are net per lineal foot based on stock lengths. If cut to special lengths, billing will be based on the entire stock lengths.

In addition to the above, standard cutting charges are as follows:

1¼ in. to 2 in. diameter, 5c. per cut. 2¾ in. diameter, 7c. per cut
2½ in. diameter, 6c. per cut. 3 in. diameter, 9c. per cut
3½ in. to 4 in. diameter, 10c.

ELECTRICAL SUPPLIES

ARMORED CABLE—Price per 1,000 ft.—5 per cent 10 days.

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$41.00 (net)	$ 62.00 (net)	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:		Lead Covered
Less than coil lots	45%	25%
Coils to 1,000 ft.	50%	30%
1,000 to 5,000 ft.	55%	35%
5,000 ft. and over	60%	40%

CONDUIT, Price per 1,000 ft.; **ELBOWS AND COUPLINGS**, Per 100 pieces, f.o.b. New York, with 10-day discount of 5 per cent.

Size In.	Conduit Black Per M	Conduit Galvanized Per M	Elbows Black Per C	Elbows Galvanized Per C	Couplings Black Per C	Couplings Galvanized Per C
¼	$61.10	$66.16	$9.90	$11.03	$5.74	$6.16
⅜	79.20	84.95	13.00	14.49	8.18	8.78
½	112.06	122.19	19.26	21.46	10.65	11.42
¾	151.62	165.31	25.65	28.33	14.76	15.78
1	181.28	197.67	34.19	37.77	18.23	19.47
1¼	248.90	265.94	62.70	69.24	24.29	25.97
1½	385.50	420.48	102.58	111.33	34.71	37.10
2	504.29	548.81	273.40	302.12	51.66	55.63
2½	633.86	688.65	604.03	667.15	69.41	74.19
3	772.62	838.59	697.06	770.99	86.76	92.73

CONDUIT BODIES AND FITTINGS—Black or galvanized.

	Less than $10 list	$10 list to $100	$100 list and over
Standard package	10%	20%	28%
Less than standard package	5%	10%	20%

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.12	D. P. D. B.	$0.31
D. P. M. L.	.16	T. P. S. B.	.35
T. P. M. L.	.27	T. P. D. B.	.47
D. P. S. B.	.16		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.27	$0.70	$1.75
T. P. M. L.	.40	1.00	2.30
D. P. S. B.	.35	.87	.....
T. P. S. B.	.67	1.50	.....
D. P. D. B.	.65	1.75	.....
T. P. D. B.	1.12	3.00	.....
T. P. to D. P. D. B.	.75	2.10	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton reinforced heavy	$21.00
No. 16 cotton reinforced heavy	24.00
No. 18 cotton reinforced light	17.00
No. 16 cotton reinforced light	20.50
No. 18 cotton Canvasite cord	16.50
No. 16 cotton Canvasite cord	18.75

NATIONAL ELECTRIC CODE FUSES, NON-REFILLABLE—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List
3-amp. to 30-amp.,	100	$0.15	3-amp. to 30-amp.,	100	$0.30
35-amp. to 60-amp.,	100	.30	35-amp. to 60-amp.,	100	.60
61-amp. to 100-amp.,	50	.90	65-amp. to 100-amp.,	50	1.50
101-amp. to 200-amp.,	25	2.00	110-amp. to 200-amp.,	25	2.50
201-amp. to 400-amp.,	25	3.60	225-amp. to 400-amp.,	25	5.50
401-amp. to 600-amp.,	10	5.50	450-amp. to 600-amp.,	10	8.00

Discount: Less 1-5th standard package, 55%; 1-5th to standard package, 60%; standard package, 65%.

RENEWABLE FUSES, ENCLOSED—List price each:

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.	$0.50	$1.10	100	10
35 to 60-amp.	1.00	1.25	100	10
65 to 100-amp.	2.00	3.00	50	5
110 to 200-amp.	4.00	5.00	25	5
225 to 400-amp.	7.50	11.00	25	1
450 to 600-amp.	11.00	16.00	10	1
450 to 600-amp.	11.00	16.00	10	1

REFILLS—

1 to 30	$0.30 ea.	$0.05	100	100
35 to 60	.05 ea.	.06	100	100
65 to 100	.10 ea.	.10	50	50
110 to 200	.15 ea.	.15	25	50
225 to 400	.30 ea.	.30	25	25
450 to 600	.60 ea.	.60	10	10

Discount Without Contract—Fuses:	
Broken carton	5%
Unbroken carton but less than std. pkg.	22%
Std. pkg.	40%
Discount Without Contract—Renewals:	
Less than std. pkg.	Net list
Standard package	40%
Discount With Contract—Fuses:	
Broken cartons	10%
Unbroken cartons but less than standard package	26%
Standard package	42%
Discount With Contract—Renewals:	
Less standard package	Net list
Standard package	42%

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package (500)	$2.85
0-30 ampere, less than standard package	3.15

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs Mazda B— Watts	Plain	Frosted	No. in Package	Pear-Shaped Bulbs or Bowl Enameled Mazda C— Watts	Clear	Frosted	No. in Package
10	$0.27	$0.32	120	50	$0.40	$0.45	60
15	.27	.32	120	75	.45	.55	60
25	.27	.32	120	100	.55	.60	24
40	.27	.32	120	150	.70	.75	24
50	.27	.32	120	200	.95	1.05	24
60	.32	.37	120	300	1.50	1.60	24
				500	2.25	2.40	12
				750	3.75	3.95	8
				1,000	4.00	4.25	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $75.00 to $300,000 net allow a discount of 15 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.18
Composition 2-piece attachment plug	.27
Swivel attachment plug	.12
Composition—2 Pc. Plug—Composition	0.8½

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o b. New York,

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$6.47	$8.48	$ 9.94	$16.00
12	8.65	11.30	12.35	21.80
10	11.50	14.43	16.17	27.36
8	16.40	18.90	21.12	37.00
6	.....	.....	29.95	.....
4	.....	.....	41.78	.....
2	.....	.....	59.35	.....
1	.....	.....	75.15	.....
0	.....	.....	106.00	.....
00	.....	.....	123.50	.....
000	.....	.....	149.00	.....
0000	.....	.....	174.80	.....

SOCKETS, BRASS SHELL—

½ In. or Pendant Cap Key Each	Keyless Each	Pull Each	⅛ In Cap Key Each	Keyless Each	Pull Each
$0.33	$0.30	$0 55	$0.39	$0.36	$0.61

Less 1-5th standard package	25%
1-5th to standard package	32%
Standard package	37%

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots	33c. lb.
Rubber tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots	33c. lb.
Wire solder, less 100 lb. 27c. lb., 100 lb. lots	29c. lb.
Soldering paste, 2 oz. cans	$1.00 doz.

ENCLOSED SWITCHES, KNIFE—Safety type, externally operated, 250 d.c or a.c., N.E.C.

TYPE "C" FUSED BOTTOM

Size, Amp.	Double Pole, Each	Three Pole, Each	Four Pole, Each
30	$4.50	$6.00	$7.25
60	7.50	8.25	10.50
100	10.50	13.00	22.50
200	16.00	20.00	36.00

Discounts:	
Less than $25.00 list value	30%
$25 to $50 list value	30–5%
$50 list value or over	35%